U.S. Coast Guard Research and Development Center
1082 Shennecossett Road, Groton, CT 06340-6096

Report No. CG-D-31-98, II

Historical Summary of Aids to Navigation Analyses

Volume II: Annotated Bibliography

FINAL REPORT
APRIL 1998

Prepared for:

U.S. Department of Transportation
United States Coast Guard
Operations (G-O)
Washington, DC 20593-0001

N O T I C E

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

The contents of this report reflect the views of the Coast Guard Research and Development Center. This report does not constitute a standard, specification, or regulation.

Marc B. Mandler, Ph.D.
Technical Director
United States Coast Guard
Research & Development Center
1082 Shennecossett Road
Groton, CT 06340-6096

Technical Report Documentation Page

1. Report No. CG-D-31-98, II	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Historical Summary of Aids to Navigation Analyses, Volume II: Annotated Bibliography		5. Report Date April 1998 6. Performing Organization Code Project No. 2420
7. Author(s) Dr. Robert L. Armacost		8. Performing Organization Report No. R&DC 09/98, II
9. Performing Organization Name and Address Department of Industrial Engineering and Management Systems University of Central Florida P.O. Box 162450 Orlando, FL 32816-2450		10. Work Unit No. 11. Contract or Grant DTCG32-97-P-E00377 13. Type of Report and Period Covered Final Report
12. Sponsoring Agency Name and Address U.S. Department of Transportation United States Coast Guard Operations (G-O) Washington, DC 20593-0001		14. Sponsoring Agency Code Commandant (G-OPN) U.S. Coast Guard Headquarters Washington, DC 20593-0001

15. Supplementary Notes
The Coast Guard technical point of contact and COTR is Clark Pritchett (860-441-2653) of the U.S. Coast Guard Research and Development Center.

16. Abstract

Volume II (this volume) contains an annotated bibliography of 137 studies, analyses, and papers that were identified as part of the historical summary of aids to navigation analyses. A detailed categorization of each of the 137 reviewed studies is also included. In addition, a total of 59 studies conducted by the Coast Guard Research and Development Center that focus on aid technology, buoy moorings, and hardware are summarized and categorized. Another 31 relevant studies have been identified that are part of the analysis in Volume I. The detailed descriptions of the studies in this annotated bibliography provided the basis for the integrated description of the studies in Volume I. In most cases, the annotated bibliography contains a more detailed description of the various studies than is contained in the main report. The annotated bibliography also offers an opportunity for incorporating these summaries in an accessible electronic database.

17. Key Words	18. Distribution Statement
aids to navigation, waterways management, buoys, aid positioning, cost analyses, waterway design, radionavigation aids, electronic charting, digital global positioning systems, service force mix	This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. SECURITY CLASSIF. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

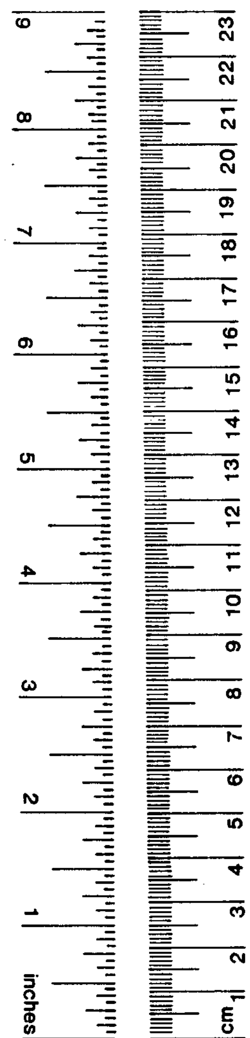
Form DOT F 1700.7 (8/72) Reproduction of form and completed page is authorized

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly).



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

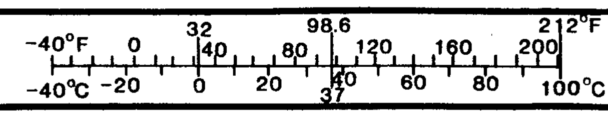


TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

The Coast Guard is continually attempting to identify ways to improve the level of services offered to mariners and reduce the costs of doing so. The Short Range Aids to Navigation (SRA) program and the Radionavigation Aids (RA) program have made major efforts to achieve that continuous improvement. There have been numerous studies over the years that have addressed buoy technology, hardware and moorings. The resulting improvements have revolutionized the servicing requirements and subsequently changed the frequency of servicing from once every three months to once every two years. Those changes have led to reduced levels of servicing resources and associated costs. Even so, aids to navigation programs represent nearly 25% of the Coast Guard's operating budget. At the same time, more accurate and reliable electronic navigation capabilities are being developed and there is the possibility of moving from "*iron to silicon*" as a primary means of navigation.

The purpose of this study is to examine the rich history of studies and analyses that have been completed over the years in support of the aids to navigation program. The objective of this examination is to identify whether there are important insights that have been observed in the past but overlooked and never implemented, and whether any of the analytical approaches that have been used in the past remain valid tools for future analyses. Specific tasks in the current study include reviewing past analyses, conducting a technology survey, and examining cost analyses. Although the statement of work limited the review to studies conducted by the Coast Guard, there are a number of studies conducted by other agencies that are relevant and are included. A total of 227 studies involving various aspects of the SRA program and portions of the RA program in the Harbor and Harbor Entrance domain have been identified. Of those, 137 studies have been reviewed in detail, 59 studies conducted by the Coast Guard Research and Development Center that have focused on buoy technology, hardware and moorings have been identified, and another 31 relevant studies have been identified through secondary references. The result represents a very substantial history of research and analysis supporting the aids to navigation programs.

This volume contains an annotated bibliography of each of the 137 studies and analyses that were reviewed in detail. Volume I of this report develops the relationships among the studies and evaluates their content and approach, and identifies what models and approaches remain useful for future studies of aids to navigation problems.

Each of the 137 studies was identified by its primary category and as many secondary categories as appropriate. The nineteen categories used for this analysis include:

- *Advanced Technology (DGPS, ECDIS, ARPA, etc.*
- *Aid Positioning*
- *Aid System Performance Measures*
- *ATON Policies*
- *Buoy/Beacon Design, Hardware and Moorings*
- *Buoy Tender Technology*
- *Customer Identification/Requirements*
- *Human Factors*
- *Information Requirements/Systems*
- *Maintenance and Logistic*

- *Modeling and Analysis*
- *Navigability, Safety, Risk*
- *Operating Costs*
- *Personnel Requirements*
- *Radionavigation Aids*
- *Servicing Mix*
- *Systems Cost Issues*
- *Vessel Positioning*
- *Waterway Design (Aid Location etc.)*

The annotated bibliography for each study includes a full citation and an abstract in addition to the classification table. The abstract is usually an expanded version of the abstract provided by the author(s).

1.0 INTRODUCTION

The Coast Guard is continually attempting to identify ways to improve the level of services offered to mariners and reduce the costs of doing so. The Short Range Aids to Navigation (SRA) program and the Radionavigation Aids (RA) program have made major efforts to achieve that continuous improvement. There have been numerous studies over the years that have addressed buoy technology, hardware and moorings. The resulting improvements have revolutionized the servicing requirements and subsequently changed the frequency of servicing from once every three months to once every two years. Those changes have led to reduced levels of servicing resources and associated costs. Even so, aids to navigation programs represent nearly 25% of the Coast Guard's operating budget. At the same time, more accurate and reliable electronic navigation capabilities are being developed and there is the possibility of moving from "*iron to silicon*" as a primary means of navigation.

As the challenge to increase services and reduce costs continues, it is valuable to review past efforts and identify whether there are important insights that have been observed in the past but overlooked and never implemented, and whether any of the analytical approaches that have been used in the past remain valid tools for future analyses. The purpose of this study is to look at the rich history of studies and analyses that have been completed over the years in support of the aids to navigation programs. Specific tasks include reviewing past analyses, conducting a technology survey, and examining cost analyses. Specifically, the statement of work required a review of all previous SRA/RA studies conducted by the Coast Guard from 1970 to the present. The technology survey task required an identification of the technologies in use at the time of the various studies and an assessment of what technologies are candidates for implementation in the future. A separate analysis of costing of program activities was envisioned in the task structure, but initial attempts by the Research and Development Center to develop such a cost structure was met with some resistance at headquarters administrative levels. Therefore, the cost segment of this historical summary includes an assessment of how costs were developed in various studies and to what extent cost was an explicit consideration.

Although the statement of work limited the review to studies conducted by the Coast Guard, there are a number of studies conducted by other agencies that are relevant and have been included. A total of 227 studies involving various aspects of the SRA program and portions of the RA program in the Harbor and Harbor Entrance domain have been identified. Of those, 137 studies have been reviewed in detail, 59 studies conducted by the Coast Guard Research and Development Center that have focused on aid technology, buoy hardware and moorings have been identified, and another 31 relevant studies have been identified through secondary references. The result represents a very substantial history of research and analysis supporting the aids to navigation programs.

The primary purpose of this volume of the final report is to provide the detailed documentation on these studies. Volume I of the final report discusses the relationships among the studies and their progression and contribution to the programs. The major contribution of this volume is a annotated bibliography for the 137 studies, analyses, and papers that were reviewed as a part of this effort. In addition to the review and annotated bibliography, all of the studies were categorized to indicate the area of primary and secondary focus. That categorization provided the basis for the discussion in Volume I. The reference listing for the annotated bibliography is included in Appendix A, and the annotated bibliography for these references is included in Appendix B. The 31 additional relevant studies (not reviewed) are included in the list of references in this volume. The 59 Coast Guard Research and Development Center studies are summarized and categorized in a later section of this report.

2.0 CLASSIFICATION OF REVIEWED AIDS TO NAVIGATION ANALYSES

In order to develop a chronological perspective of the historical development of the analyses in the annotated bibliography, they have been arranged in chronological order by year of publication. The index number is of the form YY-L-# where YY is the year of publication, L is the first letter of the first author's last name, and # is the sequential number appearing under that year and letter. The listing by index number is included in Appendix A. The alphabetical list of references is this volume includes the index number in brackets for cross reference purposes.

There are many possible means of classifying the various studies. Using the following categories, each study was identified with one **Primary** classification and as many Secondary classifications as seemed appropriate. The following categories were used:

- *Advanced Technology (DGPS, ECDIS, ARPA, etc.)*--this includes most of the electronic means of navigation including vessel bridge electronics.

- *Aid Positioning*--this involves both manual and electronic means of positioning aids.

- *Aid System Performance Measures*--this category includes studies that focused on how well an aid system worked and attempts to measure that outcome.

- *ATON Policies*--this broad category generally includes issues like discrepancy response and servicing interval policies.

- *Buoy/Beacon Design, Hardware and Moorings*--this includes a number of major studies as well as some technical studies conducted by the Research and Development Center.

- *Buoy Tender Technology*--this includes studies that examined alternative hulls as well as operating characteristics that affect the development of replacement vessels.

- *Customer Identification/Requirements*--this includes studies that addressed particular customer needs and information required for safe navigation.

- *Human Factors*--this includes studies that have a significant involvement with the role of the human in aids to navigation, including information processing and use of navigation aiding devices.

- *Information Requirements/Systems*--this includes broad information needs for the operation of the programs.

- *Maintenance and Logistics*--this primarily involves support facilities and maintenance policy issues.

- *Modeling and Analysis*--this includes studies that have used a significant amount of model development and analytical approaches to represent and evaluate aid system elements.

- *Navigability, Safety, Risk*--this includes various analyses that addressed safety and risk from a navigability perspective (generally not explicitly involving the use of aids) that would affect the design of the waterway. Broad systems risk analyses are included here.

- *Operating Costs*--this includes an explicit consideration of the cost of only the component being examined.

- *Personnel Requirements*--this includes issues involving the assignment and training of personnel qualified for aids to navigation work.

- *Radionavigation Aids*--this includes those electronic systems that were intended to provide general navigation information as well as the use of those systems.

- *Servicing Mix*--this includes a myriad of studies and analyses that address the combinations of servicing resources needed to deploy and maintain the aids to navigation systems.

- *Systems Cost Issues*--this includes a consideration of a systems cost, and may incorporate the subsystem or component/alternative cost.

- *Vessel Positioning*--this includes studies that focused on enhancing the ability of a vessel to determine its position more accurately and reliably.

- *Waterway Design (Aid Location etc.)*--this is another broad category that includes those studies and analyses that attempt to shed light on what factors are important in designing a waterway, particularly with respect to what aid related factors are important.

Using these categories, the studies, analyses, and papers in Appendix B have been classified. A separate classification table is included with each annotated entry. The classifications for all 137 reviewed aids to navigation analyses are summarized below in Table 1. The table uses the index number for each reviewed analysis. Appendix A provides the easiest cross reference to the title.

Table 1: Classification Summary of Reviewed ATON Analyses

	CLASSIFICATION																		
STUDY	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	Aid Positioning	Aid System Performance Measures	ATON Policies	Buoy/Beacon Design, Hardware and Moorings	Buoy Tender Technology	Customer Identification/Requirements	Human Factors	Information Requirements/Systems	Maintenance and Logistics	Modeling and Analysis	Navigability, Safety, Risk	Operating Costs	Personnel Requirements	Radionavigation Aids	Servicing Mix	Systems Cost Issues	Vessel Positioning	Waterway Design (Aid Location etc.)
67-U-1				S									S			P			
69-G-1							S						S			P			
69-G-2			S				S												P
70-B-1					P					S			S	S		S			
70-B-2				S	S					S			S	S		S			P
70-B-3				S	S				S	S			S	S		P			
71-C-1			P																S
71-C-2														P					
72-B-1								S				S							P
72-M-1	P											S							
72-U-1						S										P	S		
74-B-1								S				S							P
76-A-1		P																	
76-U-1																P	S		
77-A-1		S	S	P			S	S	S	S	S	S	S	S		S	S		S
77-E-1					P														
77-G-1		P																	
77-G-2		P																	
78-A-1		S	S	P			S	S			S	S					S		S
78-B-1		P																	
78-C-1			S	S			S	S			S	S				S	S		P
78-C-2		P																	
78-G-1					P														
79-B-1			S	S				S				S							P
79-D-1					P							S							
79-L-1											S					P			
80-C-1	S		S					S		S					P				S
80-M-1	P											S							
81-C-1	P							S				S							
81-C-2	S			S				S				S			P				
81-C-3	S			S				S				S			P				
81-C-4	S		S	S				S				S							P

Table 1: Classification Summary of Reviewed ATON Analyses

STUDY	CLASSIFICATION: Advanced Technology (DGPS, ECDIS, ARPA, etc.)	Aid Positioning	Aid System Performance Measures	ATON Policies	Buoy/Beacon Design, Hardware and Moorings	Buoy Tender Technology	Customer Identification/Requirements	Human Factors	Information Requirements/Systems	Maintenance and Logistics	Modeling and Analysis	Navigability, Safety, Risk	Operating Costs	Personnel Requirements	Radionavigation Aids	Servicing Mix	Systems Cost Issues	Vessel Positioning	Waterway Design (Aid Location etc.)
82-D-1	S		S									S							P
83-M-1			S	S				S				S							P
83-M-2			S	S				S				S							P
83-R-1								S			S	P							S
83-S-1	P							S				S							
83-S-2			S	S				S				S							P
83-U-1				P			S					S	S	S		S			
84-M-1			S	S				S				S							P
84-T-1					P							S							
85-H-1	S										S	P							
85-K-1	S										S	P							
85-M-1			S	S			S	S				S							P
85-M-2			S	S				S				S							P
85-O-1								S				P							S
85-S-1			S	S				S				S							P
86-G-1			P								S	S							S
86-W-1					P							S							
87-C-1											S					P			
87-U-1	S				P	S										S			
87-U-2	S				P	S										S			
87-U-3				S									S			P			
87-U-4				P								S		S		S			
87-W-1				S												P			
87-Y-1				S	S	P													
88-B-1			S	S				S				S							P
88-B-2			S	S				S				S							P
88-C-1											S					P			
88-K-1											S					P			
88-P-1															P			S	
88-U-1						P										S			
89-G-1	P			S				S				S			S				
89-T-1												S	P			S			

Table 1: Classification Summary of Reviewed ATON Analyses

	CLASSIFICATION																		
STUDY	**Advanced Technology (DGPS, ECDIS, ARPA, etc.)**	**Aid Positioning**	**Aid System Performance Measures**	**ATON Policies**	**Buoy/Beacon Design, Hardware and Moorings**	**Buoy Tender Technology**	**Customer Identification/Requirements**	**Human Factors**	**Information Requirements/Systems**	**Maintenance and Logistics**	**Modelling and Analysis**	**Navigability, Safety, Risk**	**Operating Costs**	**Personnel Requirements**	**Radionavigation Aids**	**Servicing Mix**	**Systems Cost Issues**	**Vessel Positioning**	**Waterway Design (Aid Location etc.)**
90-D-1	S				**P**														
90-K-1							D				S	S				**P**			
90-K-2	S	**P**													S				
90-L-1					**P**							S							
90-M-1	S							S				S			**P**				
90-R-1					S	**P**			S								S		
90-S-1			S	S				S				S							**P**
90-T-1												S	**P**			S			
90-W-1					**P**							S							
91-D-1					**P**								S				S		
91-D-2											S					**P**			
91-M-1			S	S							S	S							**P**
91-S-1	S	S										S			**P**			S	
91-V-1	S											**P**							
92-B-1				S							S					**P**			
92-B-2				S							S					**P**			
92-B-3				S							S					**P**			
92-C-1											S					**P**			
92-G-1	**P**										S	S							
92-I-1				S							S					**P**			
92-M-1	**P**							S	S		S	S							
92-S-1			S	S				S				S							**P**
92-S-2	S							S	S			S			**P**				
92-S-3	**P**											S		S	S				
92-U-1				S												**P**			
93-A-1	**P**								S			S			S				
93-B-1				S							S		S			**P**			
93-B-2				**P**			S					S	S		S	S			
93-G-1	**P**							S	S			S		S					
93-L-1	S							S	S			**P**		S	S				
93-M-1				S	S				S	**P**									
93-P-1	**P**			S			S		S			S			S				

Table 1: Classification Summary of Reviewed ATON Analyses

	CLASSIFICATION																		
STUDY	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	Aid Positioning	Aid System Performance Measures	ATON Policies	Buoy/Beacon Design, Hardware and Moorings	Buoy Tender Technology	Customer Identification/Requirements	Human Factors	Information Requirements/Systems	Maintenance and Logistics	Modeling and Analysis	Navigability, Safety, Risk	Operating Costs	Personnel Requirements	Radionavigation Aids	Servicing Mix	Systems Cost Issues	Vessel Positioning	Waterway Design (Aid Location etc.)
93-S-1	S	P		S								S			S			S	
94-B-1											S		S			P	S		
94-F-1				P															
94-F-2																	P		
94-M-1	P	S										S						S	
94-S-1	P						S	S	S			S							
94-S-2	P							S				S			S				
94-S-3	S	P													S			S	
94-U-1				S						P									
94-U-2				S					S				S			P			
95-B-1	S								S										P
95-B-2				S					S		S	S				P			
95-C-1												P							S
95-E-1	P											S			S				
95-G-1	P							S				S							
95-G-2	P							S				S							
95-L-1	P										S	S			S				
95-L-2	P								S						S				
95-M-1										P			S				S		
95-M-2							P	S	S		S	S					S		
95-M-3	S						S	S	S		S	S			S				P
95-S-1	P							S				S							
95-S-2	S	P									S				S				
95-U-1	S		S	S							S	S			S				P
95-W-1			S								S	S							P
96-B-1									P		S					S			
96-G-1	P							S	S			S							
96-G-2	P							S				S		S	S				
96-H-1		S					S		P			S			S				S
96-N-1							S	S	S		S	P					S		S
96-S-1	P											S			S			S	
96-S-2	P	S													S			S	

Table 1: Classification Summary of Reviewed ATON Analyses

STUDY	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	Aid Positioning	Aid System Performance Measures	ATON Policies	Buoy/Beacon Design, Hardware and Moorings	Buoy Tender Technology	Customer Identification/Requirements	Human Factors	Information Requirements/Systems	Maintenance and Logistics	Modelling and Analysis	Navigability, Safety, Risk	Operating Costs	Personnel Requirements	Radionavigation Aids	Servicing Mix	Systems Cost Issues	Vessel Positioning	Waterway Design (Aid Location etc.)
	CLASSIFICATION																		
96-V-1			S						S		S	S							**P**
96-V-2							**P**		S			S							S
97-C-1	**P**						S		S		S	S			S			S	
97-G-1	**P**							S	S			S							
97-S-1	**P**								S			S			S				
97-S-2	**P**														S			S	
97-U-1		S					S		S			S			**P**			S	
97-U-2	S						S					S	**P**	S		S	S		
98-R-1	**P**							S							S			S	

3.0 RESEARCH AND DEVELOPMENT CENTER AID TECHNOLOGY STUDIES

The 59 studies conducted by the Coast Guard Research and Development Center that focus on aid technology, buoy hardware, and moorings are summarized in Table 2. In addition, each study is categorized as follows:

- Aid Use--this includes optical and other considerations for use of visual aids.
- Power--this includes various studies that examined alternative power sources for aids.
- Mooring--this includes various systems that affect the moorings of buoys.
- Design--this includes studies that examined alternative shapes and materials for aids.

These studies were not reviewed because they were perceived to have value as historical documents, but would have little effect on future aid system designs. Current issues are included in the reviewed studies.

Table 2: Research and Development Studies focusing on Aid Technology, Buoy Hardware and Moorings

CG-D-	R&DC	Date	Title	AD-A	Aid Use	Power	Moor -ing	Design	Other
93-74	9/74	Apr 74	Design, Construction and Evaluation of a Laser Range Light	781716	☑				
	13/74	Apr 74	Illumination Levels Within Aids to Navigation Lanterns at Sunrise and Sunset	018145	☑				
125-75	16/75	Jun 75	Lightweight Anchors for Small Buoys--A State-of-the-Art Survey and Feasibility Study	029128			☑		
104-75	22/75	Sep 75	Synthetic Mooring Line Tensile Testing Procedure	035388			☑		
110-76	29/75	Oct 75	Computer Mooring Simulation of Rubber Band Mooring on a 8x26 Navigational Buoy and an 8-foot Diameter OSI Buoy	035389			☑		
106-76	5/76	Jun 76	Laboratory Evaluation of Solar Power Units for Marine Navigation	033609		☑			
56-76	10/76	Dec 75	A Feasibility Study of Extending the Jetting Process on the Western Rivers	029125			☑		
98-76	13/76	Jun 76	Development, Test and Evaluation of an Explosive Embedment Anchor for Use in the Mooring of Small Coast Guard Buoys	031310			☑		
11-77	18/76	Jun 77	Computer Program for Design and Performance Analysis of Navigation-Aid Power Systems Program Summary	047890		☑			
11-77	18/76	Jul 77	Computer Program for Design and Performance Analysis of Navigation-Aid Power Systems Program Documentation, Volume I - Software Requirements Document	047925		☑			
11-77	18/76	Jul 77	Computer Program for Design and Performance Analysis of Navigation-Aid Power Systems Program Documentation, Volume II - Users Manual	047356		☑			
11-77	18/76	Jul 77	Computer Program for Design and Performance Analysis of Navigation-Aid Power Systems Program Documentation, Volume III - Programmers Manual	047452		☑			

Table 2: Research and Development Studies focusing on Aid Technology, Buoy Hardware and Moorings

CG-D-	R&DC	Date	Title	AD-A	Aid Use	Power	Moor -ing	Design	Other
2-77	20/76	Dec 76	Lightweight Lighted Buoy Development for Use as Discrepancy Navaids	037773				☑	
5-77	1/77	Dec 76	Lightweight Low Drag Fast Water Buoys	039493				☑	
84-77	22/77	Sep 77	Coast Guard Evaluation of a Wave Activated Turbine Generator Buoy	076133		☑			
2080	28/77	Oct 77	Characterization of the Movement of Sinker During Deployment	080400			☑		
20-78	5/78	Mar 78	An Overview of Alternative Techniques for Determining Positions at Sea, with Emphasis on Applicability of Potential Use for Positioning Buoys	061997					☑
23-79	11/78	Jun 78	Economic Analysis of Solar Photovoltaic for Low Power Lighted ATON	068365		☑			
46-78	14/78	Jul 78	Proper Procedures for Use and Adjustment of the Survey Sextant	061307					☑
18-79	20/78	Dec 78	CG Marine Exposure Facilities for Naturally Aging Solar Photovoltaic Modules	067891		☑			
43-79	7/79	Mar 79	Evaluation of Solar Photovoltaic Arrays for Use on Marine Aids to Navigation	074893		☑			
5-81	12/80	Nov 80	Evaluation of Solar Photovoltaic Energy Storage for Aids to Navigation	096496		☑			
10-81	13/80	Nov 80	Testing Solar Photovoltaic Arrays for Utilization on Marine ATON	098257		☑			
22-81	5/81	Apr 81	Analytical Positioning of Aids to Navigation	107811					☑
71-81	22/81	Nov 81	Design of an Articulated Spar Buoy	110561				☑	
59-81	25/81	Sep 81	Accelerated Stress Testing of Solar Photovoltaic Modules	107378		☑			
4-82	29/81	Dec 81	Lead-Acid Batteries in Solar Photovoltaic Power Systems for Marine Aids to Navigation	112151		☑			
29-82	9/82	Jun 82	A Snapback Evaluation Technique for Synthetic Lines	119070			☑		
27-82	12/82	Jun 82	Rotational Loading of Double-Braid Line Eye Splices	118911			☑		

Table 2: Research and Development Studies focusing on Aid Technology, Buoy Hardware and Moorings

CG-D-	R&DC	Date	Title	AD-A	Aid Use	Power	Moor -ing	Design	Other
34-84	1/84	Feb 83	Side by Side Buoy Tender Evaluation Seakeeping and Maneuvering Comparison of USCGC Mallow (WLB 396) and SS KAIMALINO (Semi-Submersible Platform)	153613					☑
14-85	3/85	Mar 86	The Design and Model Testing of a Collision Tolerant Pile Structure	155485				☑	
4-87	8/85	Dec 86	Loran-C Signal Stability Study: US West Coast	183080					☑
3-86	16/85	Jan 86	An Evaluation of the Inogon Leading Mark	168108	☑				
21-86	5/86	Apr 86	Corrosive-Wear of Buoy Chain	172434			☑		
29-86	9/86	Aug 86	The Maintenance and Operation of a Small Wind Generator in the Marine Environment	174887		☑			
10-88	6/87	Aug 87	Probabilities of Detecting and Recognizing Flashing Lights on Rolling Buoys	194665	☑				
21-87	8/87	Mar 87	St. Louis Harbor Electroluminescent (EL) Bridge Lighting Project	195941	☑				
5-88	14/87	Aug 87	Detection and Identification of Fluorescent and Non-Fluorescent Daymark Materials	195942	☑				
12-88	19/87	Dec 87	Development of a Chromatic/Luminance Contrast Scale	198628	☑				
17-88	2/88	Jan 88	Corrosive-Wear of Buoy Chain	201742			☑		
15-88	5/88	Jan 88	Technical Evaluation of U.S.C.G. 180', 157', and 133' Buoy Tenders	198742					☑
11-90	9/88	Oct 89	The Development of a Charge Algorithm for the Optimized Charging of a 120V Flooded Lead-Acid Lighthouse Battery with Forced Electrolyte Destratification	208881		☑			
8-89	14/88	Oct 88	Evaluation of Fuel Cell Technology for Coast Guard Applications	210630		☑			
12-90	4/89	Nov 89	Test and Development of a Microprocessor Controlled Cycle-Charging Power System for Remote Lighthouse Applications	229103		☑			
3-90	8/89	Mar 90	Assessment of Pilot Needs for Shipboard Data and Informational Documents	222528	☑				

Table 2: Research and Development Studies focusing on Aid Technology, Buoy Hardware and Moorings

CG-D-	R&DC	Date	Title	AD-A	Aid Use	Power	Moor -ing	Design	Other
6-90	1/90	Jan 90	Navigation Performance Using Parallax Range Lights	225935	☑				
5-92	11/90	Feb 91	Worldwide Buoy Technology Survey, Vol. I	248404				☑	
5-92	11/90	Feb 91	Worldwide Buoy Technology Survey, Vol. II	248405				☑	
5-92	11/90	Feb 91	Worldwide Buoy Technology Survey, Vol. III	248406				☑	
5-92	11/90	Feb 91	Worldwide Buoy Technology Survey, Vol. IV	248407				☑	
9-90	12/90	Mar 90	Life Cycle Cost Analyses of Dayboard Systems	225936				☑	
17-90	13/90	Mar 90	Technical Evaluation of Dayboard Materials	230207				☑	
2-91	1/91	Nov 90	Non-Destructive Evaluation (NDF) of Fiberglass Marine Structures State-of-Art Review	234785				☑	
3-93	15/91	Apr 93	A Comparison of Simulated Parallax and Single-Station Range Aids to Navigation: Final Report	263460	☑				
7-91	16/91	Jul 91	Resistance and Seakeeping Data Base for USCG 157 Ft. WLM	247090					☑
17-92	9/92	Jan 93	Evaluation of 5-year Dayboard Materials	256980				☑	
2-93A	16A/92	Nov 92	Development of a Test Program to Evaluate Structural Defects in Glass Reinforced Plastic (GRP), Vol. I	263813				☑	
2-93B	16B/92	Nov 92	Development of a Test Program to Evaluate Structural Defects in Glass Reinforced Plastic (GRP), Vol. II	263814				☑	
11-93	6/93	Feb 93	Human Factors Plan for Maritime Safety	268267					☑
16-95		Jul 95	Light Emiting Diode (LED) Red Buoy Light	297734				☑	

4.0 REFERENCES

Alexander L., and Spalding, J. W., *Integrated Marine Navigation Systems of the Future*, presented at the Institute of Navigation National Technical Meeting, San Francisco, CA, January 1993. [93-A-1]

Akerstrom-Hoffman, R. A., Pizzariello, C. M., Smith, M. W., Siegel, S., Schreiber, T. E., and Gonin, I. M., A Closer Look at Mariner's Use of Electronic Chart Display and Information, *Proceedings of the Second Annual Conference and Exposition for Electronic Chart Display and Information Systems ECDIS '93*, Baltimore, MD, March 1993.

Akerstrom-Hoffman, R. A. and Smith, M. W., Mariner Performance Using Automated Navigation Systems, *Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting*, Nashville, TN, October 1994.

Armacost, R. L., *Good Intentions about Long Rang Planning for Short Range Aids to Navigation*, USCG Headquarters Aids to Navigation Division, Washington, DC, February 1977. [77-A-1]

Armacost, R.L. Status of Aids to Navigation and Deep Draft Navigation Channels: Coast Guard--Corps of Engineers Interaction, presented at the Deep Draft Navigation Channel Design Conference, Waterways Experiment Station, Vicksburg, MS, May 18, 1978. [78-A-1]

Armacost, R. L., *Cost Development for International Ice Patrol Activities*, EER Systems Corporation, Vienna, VA, June 1995. (CG-D-24-95, NTIS AD-A300155)

Associated Controls & Communications, Inc., *Operational Report of a Precise Navigation System Modified and Tested to Demonstrate Feasibility for Dredging, Channel Sweeping and Buoy Tending Operations*, Lynn, MA, December 1976. (00288). [76-A-1]

Bates, R., *Channel Lighted Buoy Model,* Field Testing and Development Center, Baltimore, MD, March 1972. (Report No. 529). [72-B-1]

Bates, R., *Preliminary Investigation of Temporal and Chromatic Methods of Marking Channels,* USCG Research and Development Center, Groton, CT, April 1974. (CG-D-96-74, CG R&DC 11/74). [74-B-1]

Bauman, F.S., Waelbrock, B.J., and Giovane, F., *Feasibility Study on the Capability for Visually Auditing Buoy Positions using VTS Radar and/or Low Light Level Television*, USCG Research and Development Center, Groton, CT, July 1978. (CG-D-45-78, CGR&DC 31/77, NTIS AD-A059755). [78-B-1]

Bertsche, W.R. and Cook, R.C., *Analysis of Visual Navigational Variables and Interactions*, Eclectech Associates, Inc., North Stonington, CT, October 1979. [79-B-1]

Bertsche, W. R., Atkins, D. A., and Smith, M. W., *Aids to Navigation Principal Findings Report on the Ship Variables Experiment: The Effect of Ship Characteristics and Related Variables on Piloting Performance*, US Coast Guard, Washington, DC, November 1981. (CG-D-55-81, NTIS AD-A108771)

Bertsche, W. R., Smith, M. W., Marino, K. L., and Cooper, R. B., *Draft SRA/RA Systems Design Manual for Restricted Waterways*, US Coast Guard, Washington, DC, February, 1982. (CG-D-77-81, NTIS AD-A113236)

Blumensteil, A. D. and Skaliotis, G. J., *Service Times for Short Range Aids to Navigation in the First CG District*, Transportation Systems Center, Cambridge, MA, 1984. (DOT-TSC-CG-569-TM-5)

Booz-Allen Applied Research Inc., *Evaluation of Plastic Versus Steel for Buoy Hulls*, Washington, DC, January 1970a. [70-B-1]

Booz-Allen Applied Research Inc., *Evaluation of Minor Marine Structures Versus Buoys*, Washington, DC, May 1970b. [70-B-2]

Booz-Allen Applied Research Inc., *Servicing Systems for Short-Range Aids to Navigation*, Washington, DC, November 1970c. [70-B-3]

Brown, G. G., Dell, R. F., and Farmer, R. A., Scheduling Coast Guard District Cutters, *Interfaces*, Vol. 26, No. 2, 59-72, March-April, 1996. [96-B-1]

Brown, K. and Schwenk, J., *Aids to Navigation Service Force Mix 2000 Project: Project Overview*, John A. Volpe National Transportation Systems Center, Cambridge, MA, July 1992. (DOT-VNTSC-CG-92-2, DOT-CG-N-01-92-1.1). [92-B-1]

Brown, K., *Analysis of USCG Replacement Stern-Loading Buoy Boat Requirements for the Aids to Navigation Mission*, John A. Volpe National Transportation Systems Center, Cambridge, MA, August, 1993. (DOT-VNTSC-CG-569-TM-5). [93-B-1]

Brown, K., Blythe, K., Schwenk J., and West, M., *Overview of the US Coast Guard Short Range Aids to Navigation Mission*, John A. Volpe National Transportation Systems Center, Cambridge, MA, 1993. (DOT-VNTSC-CG-93-2, DOT-CG-N-02-93). [93-B-2]

Brown, K., Bucciarelli, M., and Leo, F., *Analysis of Fleet Size and Private Sector Cost Comparisons for the USCG Inland Construction Tender Fleet*, John A. Volpe National Transportation Systems Center, Cambridge, MA, May 1994. (DOT-VNTSC-CG-94-4, DOT-CG-N-01-94) [94-B-1]

Brown, K., Corey, J., and Blythe, K., *Waterways Management Research and Planning Baseline Analyses: Waterways Management*, Volpe National Transportation Systems Center, Cambridge, MA, April 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-1). [95-B-1]

Brown, K., Schwenk, J., and Bucciarelli, M, *Aids to Navigation Service Force Mix 2000 Project: Volume II Development and Application of an Aids to Navigation Service Force Mix Decision Support System - Aid Assignments and Vessel Summary Reports*, John A. Volpe National Transportation Systems Center, Cambridge, MA, June 1992. (DOT-VNTSC-CG-92-2.II, DOT-CG-N-01-92-1.3). [92-B-3]

Brown, K., Schwenk, J., Bucciarelli, M, and Jacobs, M., *Aids to Navigation Service Force Mix 2000 Project: Volume I Development and Application of an Aids to Navigation Service Force Mix Decision Support System - Final Report*, John A. Volpe National Transportation Systems Center, Cambridge, MA, July 1992. (DOT-VNTSC-CG-92-2.I, DOT-CG-N-01-92-1.2). [92-B-2]

Brown, W. S., Smith, M. W., and Conway, J. A., *Positioning Experiment: Short Range Aids / Radio Aids Principal Findings: Waterway Performance Design and Evaluation Study,* Ship Analytics, Inc., North Stonington, CT, October 1988. (CG-D-09-89, 87-U-512, CGR&DC 4/88 NTIS AD-A210421). [88-B-2]

Brown, W. S., Smith, M. W., and Forstmeier, K. G., *Targets of Opportunity Experiment: Short Range Aids / Radio Aids Principal Findings: Waterway Performance Design and Evaluation Study*, Ship Analytics, Inc., North Stonington, CT, June 1988. (CG-D-3-87, 86-U-439, R&DC 15/88). [88-B-1]

Bucciarelli, M. and Brown, K., A Desktop-OR Success: Modeling Coast Guard Buoy Tender Operations, *Interfaces*, Vol. 25, No. 4, 1-11, July-August 1995. [95-B-2]

Casey, L., Watros, G., and Hall, T., *Waterways Management Research and Planning Baseline Analyses: Navigational Risk Assessment*, Volpe National Transportation Systems Center, Cambridge, MA, April 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-3). [95-C-1]

Clark, W.H., Stephenson, A.R., Bateson, R.H., Jones, J.E., Pohle, C.G., Kessler, K.M., and Sorenson, J., *Study of the Performance of Aids to Navigation Systems--Phase I, Closed Loop Model of the Process of Navigation*, Systems Control, Inc., Palo Alto, CA, March 1978. (CG-D-38-78, NTIS AD-A059891). [78-C-1]

Cline, A. K., and King, D. H., *Route Planning Model Design Report*, Pleasant Valley Software, Austin, TX, December 1987. [87-C-1]

Cline, A. K., and King, D. H., *Aids to Navigation Simulation Model: Route Planning Model*, Pleasant Valley Software, Austin, TX, June 1988. [88-C-1]

Cline, A. K., King, D. H., and Meyering, J. M., Routing and Scheduling Coast Guard Buoy Tenders, *Interfaces*, Vol. 22, May-June, 56-72, 1992. [92-C-1]

Cohen, A., Steinberg, H. and Schofer, R., *An Initial Investigation of Economic Benefits of Maritime Aids of Short Range Navigation in Ports and Waterways*, National Bureau of Standards Report 10532, Washington, DC, 1971. [71-C-1]

Cook, R. C., Marino, K. L, and Cooper, R. B., *A Simulator Study of Deepwater Port Shiphandling and Navigation Problems in Poor Visibility*, Eclectech Associates, North Stonington, CT, January 1981. (CG-D-66-80, EA-80-U-099, NTIS AD-A100656-8). [81-C-1]

Cooper, R. B., and Bertsche, W. R., *An At-Sea Experiment for the Comparative Evaluation of Radar Piloting Techniques*, Eclectech Associates, North Stonington, CT, November 1981. (EA-81-U-066). [81-C-4]

Cooper, R. B., and Marino, K. L., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays - the Mini-experiment*, Eclectech Associates, North Stonington, CT, September 1980. (CG-D-59-80, EA-80-U-88; NTIS AD-A107702). [80-C-1]

Cooper, R. B., Marino, K. L., and Bertsche, W. R., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays, the RA-1 Experiment*, Eclectech Associates, North Stonington, CT, January 1981a. (CG-D-49-81, EA-80-U-086, NTIS AD-A106941). [81-C-2]

Cooper, R. B., Marino, K. L., and Bertsche, W. R., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays, the RA-2 Experiment*, Eclectech Associates, North Stonington, CT, April 1981b. (CG-D-50-81, EA-81-U-009, NTIS AD-A1006672). [81-C-3]

Couchman, R. L., *An Overview of Alternative Techniques for Determining Positions at Sea, with Emphasis on Applicability of Potential Use for Positioning Buoys,* Research and Development Center, Groton, CT, March 1978. (CG-D-20-78, CGR&DC 5/78, NTIS AD-A061997). [78-C-2]

Coyle, J. B., *Personnel Considerations for the Coast Guard's Aids to Navigation Program*, Aids to Navigation Division (OAN), USCG Headquarters, Washington, DC, 1971. [71-C-2]

Creamer, P. M., Cho, D. L., Morris, P. B., and Pisano, J. J., *Differential GPS Mission Needs Analysis: Harbor Entry and Approach*, TASC, Reading, MA, November 1997. (TIM-08605-1). [97-C-1]

Daidola, J. C., Basar, N. S., Johnson, F. M., and Walker, R. T., *Buoy Technology Survey USCG Buoy Development Review*, M. Rosenblatt & Son Inc., New York, NY, October 1990. (CG-D-04-92, R & D C 10/90, NTIS AD-A247183). [90-D-1]

Daidola, J. C., Basar, N. S., Reyling, C.J., and Walker, R. T., *Buoy Technology Survey Recommendations for Development of Buoy Technologies*, M. Rosenblatt & Son Inc., New York, NY, June 1991. (CG-D-06-92, R & D C 17/91). [91-D-1]

Darby-Dowman, K., and Mitra, G., *Buoy Tendering - Inspection Timestamps A Prototype Model*, Brunel University, United Kingdom, September 1991. [91-D-2]

Debok, D. H., and Walker, R. T., *Analysis of "Offstation" Buoys*, Research and Development Center, Groton, CT, May 1979. (CG-D-67-79, USCG R&DC 20/79, NTIS AD-A077278). [79-D-1]

Drijfhout van Hooff, J. F., *Aids to Marine Navigation*, Volume II, Maritime Research Institute Netherlands, Report number R-238, June 1982. [82-D-1]

Ecker, W. J. and Alexander, L., The Impact of Emerging Technologies on Waterway Safety and Management, *The Bulletin*, USCG Academy, New London, CT, 27-31, August 1995. (Reprinted from *Sea Technology*, March 1995) [95-E-1]

Engelhard Minerals and Chemicals Corporation, *Fuel Cell Batteries for Operation of Aids to Navigation,* Research and Development Center, Groton, CT, October 1977. (CG-D-83-77, CGR&DC 30/77). [77-E-1]

Fremont-Smith, R., *Study of Feasibility of Changing Minor Lights, Buoy and Daybeacon Servicing Intervals*, Short Range Aids to Navigation Division, USCG Headquarters, Washington, DC, June 1994. [94-F-1]

Fremont-Smith, R., *United States Coast Guard Ocean Buoy Recapitalization Study*, Short Range Aids to Navigation Division, USCG Headquarters, Washington, DC, September 1994. [94-F-2]

Gathy, B. S., and Danahay, P. J. *A Study of the Western Rivers Aids to Navigation System*, USCG Academy, New London, CT, December 1969. [69-G-1]

Geonautics, Inc., *Study of Maritime Aids to Navigation in the Short Distance Maritime Environment*, Falls Church, VA, 1969. (Contract DOT-CG-83291-A) [69-G-2]

Giovane, F., *A Study of Aerial Semi- Precise Survey Systems for Position Auditing of Coast Guard Aids to Navigation,* Research and Development Center, Groton, CT, October 1977a. (CG-D-61-77, CGR&DC 25/77). [77-G-1]

Giovane, F., *A Feasibility Study of Aerial Imaging Techniques for Precise Aids to Navigation Position Determination,* Research and Development Center, Groton, CT, December 1977b. (CG-D-87-77, CGR&DC 33/77). [77-G-2]

Gonin, I. M., Smith, M. W., Akerstrom-Hoffman, R. A., Siegel, S., and Pizzariello, Human Factors Evaluation of Electronic Chart Display and Information Systems (ECDIS), *Proceedings of the Institute of Navigation Forty-Ninth Annual Meeting*, San Francisco, CA, January 1993.

Gonin, I. M., Smith, M. W., Dowd, M. K., Akerstrom-Hoffman, R. A., Siegel, S., Pizzariello, C. M. and Schreiber, T. E., Human Factor Analysis of Electronic Chart Display and Information Systems (ECDIS), *Navigation*, Vol. 40, No. 4, Winter, 1993-94.

Gonin, I. M. and Dowd, M. K., At-Sea Evaluation of ECDIS, *Navigation*, Vol. 41, No. 4, 435-449, Winter 1994-95.

Gonin, I., and Crowell, R., *Assessing Electronic Chart Systems*, United States Coast Guard Research and Development Center, March 1997. [97-G-1]

Gonin, I., Dowd, M. K., and Alexander, L., *Electronic Chart Display and Information System (ECDIS) Test and Evaluation, Summary Report*, United States Coast Guard Research and Development Center, December 1996. (CG-D-20-97, R&DC 39/96, NTIS AD-A329592). [96-G-2]

Grabowski, M. and Georg, J. C., Integrated Bridge Systems Performance, Expert Systems and Human Performance, *Proceedings of the Public Forum on Integrated Bridge Systems*, National Transportation Safety Board, Tysons Corner, VA, March 1996. [96-G-1]

Grabowski, M. and Sanborn, S., Knowledge-Representation and Reasoning in a Real-Time Operational Control System: The Shipboard Piloting Expert System (SPES), *Decision Sciences*, Vol. 23, No. 6, 1277-1296, 1992. [92-G-1]

Grabowski, M. and Sanborn, S., Integration and Preliminary Shipboard Observations of an Embedded Piloting Expert System, *Marine Technology*, Vol. 32, No. 3, 216-223, July 1995a. [95-G-2]

Grabowski, M. and Sanborn, S., *Shipboard Evaluation of the Shipboard Piloting Expert System (SPES)*, US Coast Guard Research and Development Center, Groton, CT, July 1995b. [95-G-1]

Grabowski, M. and Wallace, W., An Expert System for Maritime Pilots: Its Design and Assessment using Gaming, *Management Science*, Vol. 39, No. 12, 1506-1520, 1993. [93-G-1]

Greenberg, L., Bresnick, T.A., Ulvila, J.W., Marvin, F.F., Clark, G.P., and Stanley, J.G., *SRA Resource Management Final Report on Task 1: Measures of Effectiveness*, Mandex, Inc., Springfield, VA, September 1986. (CG-D-20-86, NTIS AD-A 173705). [86-G-1]

Grossetti, M., Prime, K., Campbell, M., and Moukawsher, E.J., *Buoy Reference Library*, Research and Development Center, Groton, CT, March 1978. (G-D-50-78, CGR&DC 6/78, NTIS AD-A076309). [78-G-1]

Gynther, J. W. and Smith, M. W., *Radio Aids to Navigation Requirements: the 1988 Simulator Experiment*, U.S. Coast Guard Research and Development Center, Groton, CT, November, 1989. (CG-D-08-90, NTIS AD-A226235) [89-G-1]

Heerlein, W., *A Catalog of Information Resources from a Waterways Management Perspective*, U.S. Coast Guard Research and Development Center, March 1996. [96-H-1]

Hwang, W., The Validation of a Navigator Model for Use in Computer Aided Channel Design, *Proceedings of the 6th CAORF Symposium*, 1985, A5-1 - A5-17. [85-H-1]

Ihnat, D., *Aids to Navigation Service Force Mix 2000 Project: Volume III Analysis of Multi-Mission Requirements and Development of Planning Factors for the Replacement Buoy Tender Fleet*, Short Range Aids to Navigation Division, USCG Office of Navigation Safety and Waterway Services, Washington, DC, June 1992. (DOT-VNTSC-CG-92-2.III, DOT-CG-N-01-92-1.4). [92-I-1]

Kaufman, E. J., Optimizing the Use of Compressed Time Simulation as a Screening Device for Alternative Channel Layouts, *Proceedings of the 6th CAORF Symposium*, 1985, C1-1 - C1-8. [85-K-1]

Kingsley, L. C., Klesczewski, K. S., and Smith J. A., A Logistics Model of Coast Guard Buoy Tending Operations, *Proceedings of the Winter Simulation Conference*, Washington, DC, 1988. [88-K-1]

Kingsley, L. C., Klesczewski, K. S., and Smith J. A., *Comparing US Coast Guard Buoy Tender Performance Using Simulation*, Research and Development Center, Groton, CT, June 1990. (Draft report). [90-K-1]

Krammes, S., and Crowell, R., *Demonstration of the Differential Global Positions System (DGPS) for Buoy Positioning*, United States Coast Guard Research and Development Center, October 1990. [90-K-2]

LaMance, J., Spalding J. W., and Brown, A., *Boosting Shipboard RAIM Availability*, presented at ION Fall Meeting, Palm Springs, CA, September 1995. [95-L-1]

Laxar, K., Luria, S. M. and Mandler, M. B., *A Comparison of Parallax and Single-Station Range Aids to Navigation: Final Report*, Naval Submarine Medical Research Laboratory, December 1990. [90-L-1]

Lee, J.D. and Sanquist, T.F., *Human Factors Plan for Maritime Safety: Annotated Bibliography*, Battelle Human Affairs Research Centers, Seattle, WA, February 1993a. (CG-D-08-93, R&DC 05/93, NTIS AD-A265392) [93-L-1]

Lee, J.D. and Sanquist, T.F., *Human Factors Plan for Maritime Safety*, Battelle Human Affairs Research Centers, Seattle, WA, 1993b. (CG-D-11-93)

Lozano-Perez, T., and Wesley, M. A., An Algorithm for Planning Collision-Free Paths Among Polyhedral Obstacles, *Communications of the ACM*, Vol. 22, No. 10, 560-570, October 1979. [79-L-1]

Lunday, M. T., Spalding, J. W., and Dowd, M., *Verification of USCG DGPS Broadcast Parameters*, presented at the Institute of Navigation GPS '95 Conference, Palm Springs, CA, September 1995. [95-L-2]

MacRae, B.D., Stephenson, R., Leadholm, T., and Gonin, I., *Digital Chart Database Conversion into a System Electronic Navigational Chart*, USCG Research and Development Center, Groton, CT, March 1992. (CG-D-15-92, R&DC 04/92). [92-M-1]

Maio, D., Nabrynski, J., and Long, D., *Waterways Management Research and Planning Baseline Analyses: Waterways Users*, Volpe National Transportation Systems Center, Cambridge, MA, April, 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-2). [95-M-2]

Maio, D. and Watros, G., *Waterways Management Research and Planning Baseline Analyses: Project Overview*, Volpe National Transportation Systems Center, Cambridge, MA, April 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-5). [95-M-3]

Mandler, M. B., and Smith M. W., Precision Electronic Navigation in Restricted Waterways, *Proceedings of the 46th Conference of the Institute of Navigation*, Atlantic City, NJ, June 1990. [90-M-1]

Mandler, M. B., Smith, M. W., and Gynther, J. W., Precision Electronic Navigation in Restricted Waterways, *Navigation*, Vol. 37, No. 4, Winter 1990-91.

Mandler, M. B., Smith, M. W., and Gynther, J. W., Precision Electronic Navigation in Restricted Waterways, Institute of Navigation Forty-Sixth Annual Meeting, Atlantic City, NJ, June, 1990.

Marino, K.L., Moynehan, J. D., and Smith, M.W., *Aids to Navigation Principal Findings Report: Implementation as a Test of Draft Design Manual,* Eclectech Associates Division of Ship Analytics, Inc., North Stonington CT, April 1985. (CG-D-04-85, 84-U-252, NTIS AD-A154428). [85-M-1]

Marino, K. L., Smith, M. W., and Bertsche, W. R., *Aids to Navigation Principal Findings Report: The Effect of One-Side Channel Markings and Related Conditions on Piloting Performance*, US Coast Guard, Washington, DC, December 1981a. (CG-D-56-81, NTIS AD-A111332)

Marino, K. L., Smith, M. W., and Bertsche, W. R., *Aids to Navigation Principal Findings Report: Range Light Characteristics and Their Effect on Piloting Performance*, US Coast Guard, Washington, DC, December 1981b. (CG-D-66-81, NTIS AD-A109716)

Marino, K. L., Smith, M. W., and Moynehan J. D., *Aids to Navigation SRA Supplemental Experiment Principal Findings: Performance of Short Range Aids under Varied Shiphandling Conditions*, Eclectech Associates Division of Ship Analytics, Inc., North Stonington, CT, September 1984. (CG-D-03-84, 83-U-166, NTIS AD-A148366). [84-M-1]

Mazurkiewicz, J. and Smith, M.W., *The Effect of Ship Inherent Controllability on Piloted Performance: Evaluation and Prediction*, Interim Report, USCG Research and Development Center, Groton, CT, September 1991. (CG-D-10-93, R&DC 21/90). [91-M-1]

McIntosh, J. A., *Follow-the-Wire Marine Aid to Navigation System: Report on an Initial Demonstration Installation*, Commandant(DAS), USCG Headquarters, Washington, DC, May 1972. [72-M-1]

McLeish, D. B., and Alexander, L., *Buoy Tending with ECDIS: The Future is Now*, presented at the XIIIth IALA Conference, Honolulu, HI, February 1994. [94-M-1]

Millbach, M. A., *Error Sensitivity Model - Second Interim Report,* Research and Development Center, Groton, CT, April 1980. (CG-D-53-80, R&DC 8/80, NTIS AD-A089277). [80-M-1]

Moynehan, J. D., and Smith, M.W., *Aids to Navigation Systems and Meeting Traffic,* Eclectech Associates Division of Ship Analytics, Inc., North Stonington, CT, June 1985. (CG-D-19-85, 85-U-326 & 26-8403-02, NTIS AD-A157905). [85-M-2]

Mueller, T., Loomis, P., and Sheynblat, L., *Wide Area DGPS Design Issues Study*, USCG Research and Development Center, Groton, CT, January 1995. (CG-D-1-95, NTIS AD-A290240).

Multer, J., and Smith, M.W., *Aids to Navigation Turn Lights Principal Findings: Effect of Turn Lighting Characteristics, Buoy Arrangement, and Ship Size on Nighttime Piloting,* Eclectech Associates, Inc., North Stonington, CT, February 1983a (CG-D-49-82, EA-82-U-054, NTIS AD-A126080). [83-M-1]

Multer, J. and Smith, M. W., *Aids to Navigation Radar I, Principal Findings: Performance in Limited Visibility of Short Range Aids with Passive Reflectors*, Eclectech Associates, Inc., North Stonington, CT, December 1983b. (CG-D-79-83, 83-U-143, NTIS AD-A137596). [83-M-2]

Murphy, J. M., *Buoy Maintenance Study Part I*, USCG Maintenance and Logistics Command, Atlantic, September 1993. [93-M-1]

Murphy, J. M., *Buoy Maintenance Study Part II*, USCG Maintenance and Logistics Command, Atlantic, February 1995. [95-M-1]

National Research Council, *Vessel Navigation and Traffic Services for Safe and Efficient Ports and Waterways, Interim Report*, Marine Board, NRC, Washington, DC, 1996. [96-N-1]

O'Hara, J. M., and Brown, W. S., *An Investigation of the Relative Safety of Alternative Navigational System Designs for the New Sunshine Skyway Bridge: A CAORF Simulation*, Computer Aided Operations Research Facility (CAORF), September 1985. (CAORF 26-8232-04). [85-O-1]

Pietraszewski, D., Spalding, J., Viehweg, C, and Luft, L., U.S. Coast Guard Differential GPS Navigation Field Test Findings, *Navigation: Journal of the Institute of Navigation*, Vol. 31, No. 1, 55-72, 1988. [88-P-1]

Polant, R.M., The Coast Guard--in the 21st Century, *The Bulletin*, USCG Academy Alumni Association, New London, CT, February 1993. [93-P-1]

Reik, J. R. and Hargis, S. C., Coastal Risk Management, *Proceedings of the 5th CAORF Symposium*, 1983, B2-1 - B2-12. [83-R-1]

Rosenblatt & Son, Inc., *Users Manual for the Buoy Technology Information System (BTIS)*, August 1990. [90-R-1]

Ryan, S., Petovello, M., and Lachapelle, G., Augmentation of GPS for Ship Navigation in Constricted Water Ways, *Proceedings of ION NTM 98*, Long Beach, CA, January 1998. [98-R-1]

Sanquist, T.F., Lee, J.D. and Rothblum, A.M., *Cognitive Analysis of Navigation Tasks: A Tool for Training Assessment and Equipment Design*, Battelle Human Affairs Research Centers, Seattle, WA, April 1994. (CG-D-19-94, R&DC 12/94, NTIS AD-A284392). [94-S-1]

Schroeder, K. R., Smith, M. W., and Moynehan, J. D., Aids to Navigation System and Meeting Traffic, *Proceedings of the 6th CAORF Symposium*, May 1985, B8-1 - B8-9. [85-S-1]

Schryver, J. C., *Evaluation of ARPA Display Modes and Traffic Assessment Through CAORF Simulation of Collision Avoidance Situations*, CAORF, National Maritime Research Center, Kings Point, NY, October 1983. (CAORF 13-8128-02, DTMA 91-82-D-20004). [83-S-1]

Skaliotis, G. J., *Short Range Aids Service Force Mix Methodology Development*, Transportation Systems Center, Cambridge, MA, 1984. (DOT-TSC-CG-569-TM-1)

Skaliotis, G. J., *Port Planning for Seagoing Buoy Tender (WLB) Attrition*, Transportation Systems Center, Cambridge, MA, September 1987a. (DOT-TSC-CG-88-2, I)

Skaliotis, G. J., *Service Vessel Analysis, Volume I: Seagoing and Coastal Vessel Requirements for Servicing Aids to Navigation*, Transportation Systems Center, Cambridge, MA, September 1987b. (DOT-TSC-CG-87-2, I)

Smith, M.W., *Waterway Design Manual*, USCG Research and Development Center, Groton, CT, September 1992. (CG-D-18-92, R&DC 01/92, NTIS AD-A257030). [92-S-1]

Smith, M. W., Akerstrom-Hoffman, R., Pizzariello, C. M, Siegel, S. I., and Gonin, I. M., Mariner's Use of Automated Navigation Systems, *Transportation Research Record 1464*, 1994. [94-S-2]

Smith, M. W., Akerstrom-Hoffman, R., Pizzariello, C. M, Siegel, S. I., Schreiber, T. E., and Gonin, I. M., *Human Factors Evaluation of Electronic Chart Display and Information Systems (ECDIS)*, Department of Transportation, United States Coast Guard Research and Development Center, February 1995. (CG-D-12-95, R&DC 10/93, MSI/CAORF 26-9038-01A, NTIS AD-A295524). [95-S-1]

Smith, M. W. and Bertsche, W. R., *Aids to Navigation Principal Findings Report on the CAORF Experiment: The Performance of Visual Aids to Navigation as Evaluated by Simulation*, US Coast Guard, Washington, DC, February 1981a. (CG-D-51-81, NTIS AD-A107045)

Smith, M. W. and Bertsche, W. R., *Aids to Navigation Principal Findings Report on the Channel Width Experiment: The Effect of Channel Width and Related Variables on Piloting Performance*, US Coast Guard, Washington, DC, December 1981b. (CG-D-54-81, NTIS AD-A111337)

Smith, M. W., Bertsche, W. R., and Schroeder, K. R., The Use of Real Time Man-in-the-Loop Simulation to Measure the Effectiveness of Aids to Navigation Configurations, *Sixteenth Annual Marine Technology Conference*, Washington, DC, October 1980.

Smith, M. W., Bertsche, W. R., and Schroeder, K. R., An Evaluation of Assumptions Needed for Generic Research on Shiphandling Simulators, *Proceedings of the Second International Conference on Marine Simulation, MARSIM '81*, Kings Point, NY, June 1981.

Smith, M. W., and Mandler, M. B., Human Factors Evaluations of Electronic Navigation Systems, *Proceedings of the First Annual Conference and Exposition for Electronic Chart Display and Information Systems: ECDIS '92*, Baltimore, MD, February 1992, 113-122. [92-S-2]

Smith, M. W., Marino, K. L., and Multer, J., *Short Range Aids to Navigation Systems Design Manual for Restricted Waterways*, US Coast Guard, Washington, DC, June 1985. (CG-D-18-85; NTIS AD-A158213)

Smith, M. W., Marino, K. L., Multer, J., and Moynehan, J. D., *Aids to Navigation Principal Findings Report: Validation for a Simulator-based Design Project*, US Coast Guard, Washington, DC, July 1984. (CG-D-06-84; NTIS AD-A146789)

Smith, M.W., Mazurkiewicz, J., and Brown, W.K., *The Effect of Ship Inherent Controllability on Piloted Performance: The Simulator Experiment*, Ship Analytics, Inc., North Stonington, CT, October 1990. (CG-D-10-90, R&DC 16/90, NTIS AD-A228968). [90-S-1]

Smith, M. W., Multer, J, and Schroeder, K. R., Simulator Evaluation of Turn Lighting Effectiveness for Nighttime Piloting, *Proceedings of the 5th CAORF Symposium*, 1983, B3-1 - B3-11. [83-S-2]

Smith, M. W. and Schroeder, K. R., Simulator Evaluation of Turn Lighting Effectiveness for Nighttime Piloting, *Proceedings Fifth Annual CAORF Symposium*, National Maritime Research Center, Kings Point, NY, May 1983.

Smith, M. W. and Schroeder, K. R., Enhancing Transfer to Sea for a Simulator-Based Research Project, *Proceedings MARSIM '84*, Rotterdam, The Netherlands, June 1984.

Spalding, J. W., and Alexander, L., *United States Coast Guard Integrated Ice Navigation System Research*, United States Coast Guard Research and Development Center, January 1997. [97-S-1]

Spalding, J. W., and Crowell, R. D., *Performance Test Results of DGPS and DPS Testing on USCGC Juniper (WLB-201)*, United States Coast Guard Research and Development Center, September 1996. [96-S-2]

Spalding, J. W., and Crowell, R. D., *Performance Test Results of DGPS and DPS Testing on USCGC IDA LEWIS (WLM-551)*, United States Coast Guard Research and Development Center, July 1997. [97-S-2]

Spalding, J. W., and van Diggelen, F., *Positioning United Sates Aids-to-Navigation Around the World*, presented at the Institute of Navigation GPS '95 Conference, Palm Springs, CA, September 1995. [95-S-2]

Spalding, J. W., Flynn, S., Milne, W. and van Diggelen, F., *Interim Report on Servicing and Positioning Aids-to-Navigation with DGPS Incorporating Receiver Autonomous Integrity Monitoring*, United States Coast Guard Research and Development Center, April 1994. [94-S-3]

Spalding, J. W., Flynn, S., and van Diggelen, F., *Servicing and Positioning Aids-to-Navigation with DGPS*, Institute of Navigation GPS '93 Conference, Salt Lake City, UT, 1993. [93-S-1]

Spalding, J. W., Lunday, M. T., and Dowd, M. K., *Differential Beacon Receiver Testing*, United States Coast Guard Research and Development Center, June 1996. (CG-D-24-96, R&DC 18/96, NTIS AD-A317835). [96-S-1]

Spalding, J., Krammes, S., and Pietraszewski, D., *Status of Prototype USCG DGPS Broadcasts from the Montauk Point, New York Radiobeacon*, US Coast Guard Research and Development Center, Groton, CT, March 1991. [91-S-1]

Stewart, R. D., and Alexander, L., *Evaluation of Remote Vessel Tracking and Control: Preliminary Trials*, presented at the 1992 RTCM Annual Assembly Meeting, Bal Harbor, FL, 1992. [92-S-3]

Thacker, J.R., *An Evaluation of Flashtube Signal Characteristics*, ,Research and Development Center, Groton, CT, August 1984. (CG-D-26-84, CGR&DC 13/84, NTIS AD-A149569). [84-T-1]

Thacker, J.R., *Final Report on United States Coast Guard Aids to Navigation Servicing Trial Contracts*, Draft Report, USCG Headquarters, Washington, DC, October 1989. [89-T-1]

Tung, F.F.C., Skaliotis, G.J., Goeddel, D., Flahive, D., and Cook, R., *Evaluation of Contracting the Servicing of Short Range Aids to Navigation*, Transportation Systems Center, Cambridge, MA, August 1990. [90-T-1]

US Coast Guard, *Issue Paper--Coast Guard Buoy Tender Utilization*, Office of Operations Plans and Programs Staff, Washington, DC, 1967. [67-U-1]

US Coast Guard, *Analysis of Alternative Programs for Replacement of Offshore Buoy Tender Fleet*, Aids to Navigation Division, Washington, DC, 1971.

US Coast Guard , *Analysis to Define Present and Future Requirements for Inland Construction Tenders*, Aids to Navigation Division (WAN-5), Washington, DC, 1972. [72-U-1]

US Coast Guard, *Determination of Construction Tender Requirements*, Aids to Navigation Division (WAN-5), Washington, DC, 1976. [76-U-1]

US Coast Guard, *United States Coast Guard Military Personnel Requirements*, Washington, DC, October 1980.

US Coast Guard, *S-L-E-P Cost Effectiveness Study*, Final Draft, Washington, DC, September 1982.

US Coast Guard, Office of Navigation, *Short Range Aids to Navigation Study*, Washington, DC, June 1983. [83-U-1]

US Coast Guard, Short Range Aids to Navigation Division, *Evaluation of Impact in Advances in Buoy Technology on Replacement of WLB/WLM Capability*, Washington, DC, January 1987a. [87-U-1]

US Coast Guard, Systems Technology Division, *Evaluation of Impact of Advances in Buoy Technology on Replacement of WLB/WLM Capability*, Washington, DC, March 1987b. [87-U-2]

US Coast Guard, Short Range Aids to Navigation Division, Office of Navigation, Chief, *WLB Multi-Mission Utilization and Replacement of WLB Capability*, Washington, DC, June 1987c. [87-U-3]

US Coast Guard, Short Range Aids to Navigation Division, Signal Management Branch, *An Evaluation of Servicing and Discrepancy Policies for Short Range Aids to Navigation*, Washington, DC, June 1987d. [87-U-4]

US Coast Guard, Office of Navigation Safety and Waterway Services, Chief, *WLB/WLM Replacement Sponsor's Requirements Documents*, Washington, DC, November 1988. [88-U-1]

US Coast Guard, Office of Navigation Safety and Waterway Services, Chief, *Aids to Navigation Service Force Mix*, Washington, DC, February 1992. [92-U-1]

US Coast Guard, Office of Engineering, Logistics and Development, and Office of Navigation Safety and Waterway Services, *Base/Support Center Industrial Support Roles Focus Group*, Washington, DC, 18 March 1994a. [94-U-1]

US Coast Guard, Short Range Aids to Navigation Division, Fleet Development Team, *Short Range Aids to Navigation Mission Analysis SRAMA*, Washington, DC, April 1994b. [94-U-2]

US Coast Guard, *Waterway Analysis and Management System Completion Guide*, Washington, DC, January 1995. [95-U-1]

US Coast Guard, *Aids to Navigation Manual - Administration,* Commandant Instruction M165000.7, Washington, DC.

US Coast Guard, *Aids to Navigation Manual - Positioning,* Commandant Instruction M165000.1B, Washington, DC.

US Department of Transportation/Department of Defense, *1996 Federal Radionavigation Plan*, Washington, DC, July 1997. [97-U-1]

US General Accounting Office, *Coast Guard Challenges for Addressing Budget Constraints*, GAO/RCED-97-110, Washington, DC, May 1997. [97-U-2]

US Treasury Department, *Study of the Roles and Missions of the United States Coast Guard*, Washington, DC, 1962.

Volpe National Transportation Systems Center, *Port Needs Study (Vessel Traffic Services Benefits) Study Overview*, Cambridge, MA, August 1991. [91-V-1]

Volpe National Transportation Systems Center, *Waterways Evaluation Tool Functional Requirements*, Initial Draft, Cambridge, MA, March 15, 1996a. [96-V-1]

Volpe National Transportation Systems Center, *Waterways User Groups Characterized According to the Navigational Requirements of the Vessel Operators*, Final Report, Cambridge, MA, August 1996b. [96-V-2]

Walker, R.T., Pritchett, C.W., Lincoln, W.B., and Stevens, M.J., *U.S. Coast Guard Buoy Tenders: Historical and Projected Usage*, USCG Research and Development Center, Groton, CT, June 1987. (CG-D-18-87, R&DC 12/87, NTIS AD-A183653). [87-W-1]

Winkeller, R., Watros, G., and Weber, A., *Waterways Management Research and Planning Baseline Analyses: Management Systems Effectiveness and Benefits Estimating*, Volpe National Transportation Systems Center, Cambridge, MA, April 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-4). [95-W-1]

Winslow, T.S., and Mandler, M. B., *An Evaluation of the Hypothesis that Laser Light is More Conspicuous than Incandescent Light,* Research and Development Center, Groton, CT, May 1986. (CG-D-16-86, CGR&DC 8/86, NTIS AD-A170823). [86-W-1]

Wroblewski, M. R., and Mandler, M. B., *Detecting Buoy Lights: Effects of Motion and Lantern Divergence*, Research and Development Center, Groton, CT, March 1990 (CG-D-07-90, R&DC 05/90, NTIS AD-A225937). [90-W-1]

Young, R., Allen, S., Bitting, K., Kohler, C., Walker, R., Wyland, R., and Pietraszewski, D., *Survey of Technology with Possible Applications to United States Coast Guard Buoy Tenders: Volume I–Technology Assessment*, USCG Research and Development Center, Groton, CT, September 1987. (CG-D-06-88, R&DC 04/87, NTIS AD-A193918). [87-Y-1]

HISTORICAL SUMMARY OF AIDS TO NAVIGATION ANALYSES

APPENDIX A:

INDEXED REFERENCE LIST FOR THE ANNOTATED BIBLIOGRAPHY OF REVIEWED AIDS TO NAVIGATION ANALYSES

The following studies, analyses, and papers have been reviewed as part of the historical summary of aids to navigation analyses. An annotated bibliography for these references is included in Appendix B. In order to develop a chronological perspective of the historical development of these analyses, they have been arranged in chronological order by year of publication. The index is of the form YY-L-# where YY is the year of publication, L is the first letter of the first author's last name, and # is the sequential number appearing under that year and letter. An alphabetical list of references is included in the main portion of this report. Each reference in that listing for which an entry is included in the annotated bibliography is cross-referenced to this index number.

67-U-1 US Coast Guard, *Issue Paper--Coast Guard Buoy Tender Utilization*, Office of Operations Plans and Programs Staff, Washington, DC, 1967.

69-G-1 Gathy, B. S., and Danahay, P. J. *A Study of the Western Rivers Aids to Navigation System*, USCG Academy, New London, CT, December 1969.

69-G-2 Geonautics, Inc., *Study of Maritime Aids to Navigation in the Short Distance Maritime Environment*, Falls Church, VA, 1969. (Contract DOT-CG-83291-A)

70-B-1 Booz . Allen Applied Research Inc., *Evaluation of Plastic Versus Steel for Buoy Hulls*, Washington, DC, January 1970.

70-B-2 Booz . Allen Applied Research Inc., *Evaluation of Minor Marine Structures Versus Buoys*, Washington, DC, May 1970.

70-B-3 Booz . Allen Applied Research Inc., *Servicing Systems for Short-Range Aids to Navigation*, Washington, DC, November 1970.

71-C-1 Cohen, A., Steinberg, H. and Schofer, R., *An Initial Investigation of Economic Benefits of Maritime Aids of Short Range Navigation in Ports and Waterways*, National Bureau of Standards Report 10532, Washington, DC, 1971.

71-C-2 Coyle, J. B., *Personnel Considerations for the Coast Guard's Aids to Navigation Program*, Aids to Navigation Division (OAN), USCG Headquarters, Washington, DC, 1971.

72-B-1 Bates, R., *Channel Lighted Buoy Model,* Field Testing and Development Center, Baltimore, MD, March 1972. (Report No. 529).

72-M-1 McIntosh, J. A., *Follow-the-Wire Marine Aid to Navigation System: Report on an Initial Demonstration Installation*, Commandant(DAS), USCG Headquarters, Washington, DC, May 1972.

72-U-1 US Coast Guard , *Analysis to Define Present and Future Requirements for Inland Construction Tenders*, Aids to Navigation Division (WAN-5), Washington, DC, 1972.

74-B-1 Bates, R., *Preliminary Investigation of Temporal and Chromatic Methods of Marking Channels,* USCG Research and Development Center, Groton, CT, April 1974. (CG-D-96-74, CG R&DC 11/74).

76-A-1 Associated Controls & Communications, Inc., *Operational Report of a Precise Navigation System Modified and Tested to Demonstrate Feasibility for Dredging, Channel Sweeping and Buoy Tending Operations*, Lynn, MA, December 1976. (00288).

76-U-1 US Coast Guard, *Determination of Construction Tender Requirements*, Aids to Navigation Division (WAN-5), Washington, DC, 1976.

77-A-1 Armacost, R. L., *Good Intentions about Long Rang Planning for Short Range Aids to Navigation*, USCG Headquarters Aids to Navigation Division, Washington, DC, February 1977.

77-E-1 Engelhard Minerals and Chemicals Corporation, *Fuel Cell Batteries for Operation of Aids to Navigation,* Research and Development Center, Groton, CT, October 1977. (CG-D-83-77, CGR&DC 30/77).

77-G-1 Giovane, F., *A Study of Aerial Semi- Precise Survey Systems for Position Auditing of Coast Guard Aids to Navigation,* Research and Development Center, Groton, CT, October 1977. (CG-D-61-77, CGR&DC 25/77).

77-G-2 Giovane, F., *A Feasibility Study of Aerial Imaging Techniques for Precise Aids to Navigation Position Determination,* Research and Development Center, Groton, CT, December 1977. (CG-D-87-77, CGR&DC 33/77).

78-A-1 Armacost, R.L. Status of Aids to Navigation and Deep Draft Navigation Channels: Coast Guard--Corps of Engineers Interaction, presented at the Deep Draft Navigation Channel Design Conference, Waterways Experiment Station, Vicksburg, MS, May 18, 1978.

78-B-1 Bauman, F.S., Waelbrock, B.J., and Giovane, F., *Feasibility Study on the Capability for Visually Auditing Buoy Positions using VTS Radar and/or Low Light Level Television*, USCG Research and Development Center, Groton, CT, July 1978. (CG-D-45-78, CGR&DC 31/77, NTIS AD-A059755).

78-C-1 Clark, W.H., Stephenson, A.R., Bateson, R.H., Jones, J.E., Pohle, C.G., Kessler, K.M., and Sorenson, J., *Study of the Performance of Aids to Navigation Systems--Phase I, Closed Loop Model of the Process of Navigation*, Systems Control, Inc., Palo Alto, CA, March 1978. (CG-D-38-78, NTIS AD-A059891).

78-C-2 Couchman, R. L., *An Overview of Alternative Techniques for Determining Positions at Sea, with Emphasis on Applicability of Potential Use for Positioning Buoys,* Research and Development Center, Groton, CT, March 1978. (CG-D-20-78, CGR&DC 5/78, NTIS AD-A061997).

78-G-1 Grossetti, M., Prime, K., Campbell, M., and Moukawsher, E.J., *Buoy Reference Library,* Research and Development Center, Groton, CT, March 1978. (G-D-50-78, CGR&DC 6/78, NTIS AD-A076309).

79-B-1 Bertsche, W.R. and Cook, R.C., *Analysis of Visual Navigational Variables and Interactions*, Eclectech Associates, Inc., North Stonington, CT, October 1979.

79-D-1 Debok, D. H., and Walker, R. T., *Analysis of "Offstation" Buoys*, Research and Development Center, Groton, CT, May 1979. (CG-D-67-79, USCG R&DC 20/79, NTIS AD-A077278).

79-L-1 Lozano-Perez, T., and Wesley, M. A., An Algorithm for Planning Collision-Free Paths Among Polyhedral Obstacles, *Communications of the ACM*, Vol. 22, No. 10, 560-570, October 1979.

80-C-1 Cooper, R. B., and Marino, K. L., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays - the Mini-experiment*, Eclectech Associates, North Stonington, CT, September 1980. (CG-D-59-80, EA-80-U-88; NTIS AD-A107702).

80-M-1 Millbach, M. A., *Error Sensitivity Model - Second Interim Report,* Research and Development Center, Groton, CT, April 1980. (CG-D-53-80, R&DC 8/80, NTIS AD-A089277).

81-C-1 Cook, R. C., Marino, K. L, and Cooper, R. B., *A Simulator Study of Deepwater Port Shiphandling and Navigation Problems in Poor Visibility*, Eclectech Associates, North Stonington, CT, January 1981. (CG-D-66-80, EA-80-U-099, NTIS AD-A100656-8).

81-C-2 Cooper, R. B., Marino, K. L., and Bertsche, W. R., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays, the RA-1 Experiment*, Eclectech Associates, North Stonington, CT, January 1981. (CG-D-49-81, EA-80-U-086, NTIS AD-A106941).

81-C-3 Cooper, R. B., Marino, K. L., and Bertsche, W. R., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays, the RA-2 Experiment*, Eclectech Associates, North Stonington, CT, April 1981. (CG-D-50-81, EA-81-U-009, NTIS AD-A1006672).

81-C-4 Cooper, R. B., and Bertsche, W. R., *An At-Sea Experiment for the Comparative Evaluation of Radar Piloting Techniques*, Eclectech Associates, North Stonington, CT, November 1981. (EA-81-U-066).

82-D-1 Drijfhout van Hooff, J. F., *Aids to Marine Navigation*, Volume II, Maritime Research Institute Netherlands, Report number R-238, June 1982.

83-M-1 Multer, J., and Smith, M.W., *Aids to Navigation Turn Lights Principal Findings: Effect of Turn Lighting Characteristics, Buoy Arrangement, and Ship Size on Nighttime Piloting,* Eclectech Associates, Inc., North Stonington, CT, February 1983 (CG-D-49-82, EA-82-U-054, NTIS AD-A126080).

83-M-2 Multer, J. and Smith, M. W., *Aids to Navigation Radar I, Principal Findings: Performance in Limited Visibility of Short Range Aids with Passive Reflectors*, Eclectech Associates, Inc., North Stonington, CT, December 1983. (CG-D-79-83, 83-U-143, NTIS AD-A137596).

83-R-1 Reik, J. R. and Hargis, S. C., Coastal Risk Management, *Proceedings of the 5th CAORF Symposium*, 1983, B2-1 - B2-12.

83-S-1 Schryver, J. C., *Evaluation of ARPA Display Modes and Traffic Assessment Through CAORF Simulation of Collision Avoidance Situations*, CAORF, National Maritime Research Center, Kings Point, NY, October 1983. (CAORF 13-8128-02, DTMA 91-82-D-20004).

83-S-2 Smith, M. W., Multer, J, and Schroeder, K. R., Simulator Evaluation of Turn Lighting Effectiveness for Nighttime Piloting, *Proceedings of the 5th CAORF Symposium*, 1983, B3-1 - B3-11.

83-U-1 US Coast Guard, Office of Navigation, *Short Range Aids to Navigation Study*, Washington, DC, June 1983.

84-M-1 Marino, K. L., Smith, M. W., and Moynehan J. D., *Aids to Navigation SRA Supplemental Experiment Principal Findings: Performance of Short Range Aids under Varied Shiphandling Conditions*, Eclectech Associates Division of Ship Analytics, Inc., North Stonington, CT, September 1984. (CG-D-03-84, 83-U-166, NTIS AD-A148366).

84-T-1 Thacker, J.R., *An Evaluation of Flashtube Signal Characteristics,* ,Research and Development Center, Groton, CT, August 1984. (CG-D-26-84, CGR&DC 13/84, NTIS AD-A149569).

85-H-1 Hwang, W., The Validation of a Navigator Model for Use in Computer Aided Channel Design, *Proceedings of the 6th CAORF Symposium*, 1985, A5-1 - A5-17.

85-K-1 Kaufman, E. J., Optimizing the Use of Compressed Time Simulation as a Screening Device for Alternative Channel Layouts, *Proceedings of the 6th CAORF Symposium*, 1985, C1-1 - C1-8.

85-M-1 Marino, K.L., Moynehan, J. D., and Smith, M.W., *Aids to Navigation Principal Findings Report: Implementation as a Test of Draft Design Manual,* Eclectech Associates Division of Ship Analytics, Inc., North Stonington CT, April 1985. (CG-D-04-85, 84-U-252, NTIS AD-A154428).

85-M-2 Moynehan, J. D., and Smith, M.W., *Aids to Navigation Systems and Meeting Traffic,* Eclectech Associates Division of Ship Analytics, Inc., North Stonington, CT, June 1985. (CG-D-19-85, 85-U-326 & 26-8403-02, NTIS AD-A157905).

85-O-1 O'Hara, J. M., and Brown, W. S., *An Investigation of the Relative Safety of Alternative Navigational System Designs for the New Sunshine Skyway Bridge: A CAORF Simulation*, Computer Aided Operations Research Facility (CAORF), September 1985. (CAORF 26-8232-04).

85-S-1 Schroeder, K. R., Smith, M. W., and Moynehan, J. D., Aids to Navigation System and Meeting Traffic, *Proceedings of the 6th CAORF Symposium*, May 1985, B8-1 - B8-9.

86-G-1 Greenberg, L., Bresnick, T.A., Ulvila, J.W., Marvin, F.F., Clark, G.P., and Stanley, J.G., *SRA Resource Management Final Report on Task 1: Measures of Effectiveness*, Mandex, Inc., Springfield, VA, September 1986. (CG-D-20-86, NTIS AD-A 173705).

86-W-1 Winslow, T.S., and Mandler, M. B., *An Evaluation of the Hypothesis that Laser Light is More Conspicuous than Incandescent Light,* Research and Development Center, Groton, CT, May 1986. (CG-D-16-86, CGR&DC 8/86, NTIS AD-A170823).

87-C-1 Cline, A. K., and King, D. H., *Route Planning Model Design Report*, Pleasant Valley Software, Austin, TX, December 1987.

87-U-1 US Coast Guard, Short Range Aids to Navigation Division, *Evaluation of Impact in Advances in Buoy Technology on Replacement of WLB/WLM Capability*, Washington, DC, January 1987.

87-U-2 US Coast Guard, Systems Technology Division, *Evaluation of Impact of Advances in Buoy Technology on Replacement of WLB/WLM Capability*, Washington, DC, March 1987.

87-U-3 US Coast Guard, Short Range Aids to Navigation Division, Office of Navigation, Chief, *WLB Multi-Mission Utilization and Replacement of WLB Capability*, Washington, DC, June 1987.

87-U-4 US Coast Guard, Short Range Aids to Navigation Division, Signal Management Branch, *An Evaluation of Servicing and Discrepancy Policies for Short Range Aids to Navigation*, Washington, DC, June 1987.

87-W-1 Walker, R.T., Pritchett, C.W., Lincoln, W.B., and Stevens, M.J., *U.S. Coast Guard Buoy Tenders: Historical and Projected Usage*, USCG Research and Development Center, Groton, CT, June 1987. (CG-D-18-87, R&DC 12/87, NTIS AD-A183653).

87-Y-1 Young, R., Allen, S., Bitting, K., Kohler, C., Walker, R., Wyland, R., and Pietraszewski, D., *Survey of Technology with Possible Applications to United States Coast Guard Buoy Tenders: Volume I--Technology Assessment*, USCG Research and Development Center, Groton, CT, September 1987. (CG-D-06-88, R&DC 04/87, NTIS AD-A193918).

88-B-1 Brown, W. S., Smith, M. W., and Forstmeier, K. G., *Targets of Opportunity Experiment: Short Range Aids / Radio Aids Principal Findings: Waterway Performance Design and Evaluation Study*, Ship Analytics, Inc., North Stonington, CT, June 1988. (CG-D-3-87, 86-U-439, R&DC 15/88).

88-B-2 Brown, W. S., Smith, M. W., and Conway, J. A., *Positioning Experiment: Short Range Aids / Radio Aids Principal Findings: Waterway Performance Design and Evaluation Study,* Ship Analytics, Inc., North Stonington, CT, October 1988. (CG-D-09-89, 87-U-512, CGR&DC 4/88 NTIS AD-A210421).

88-C-1 Cline, A. K., and King, D. H., *Aids to Navigation Simulation Model: Route Planning Model*, Pleasant Valley Software, Austin, TX, June 1988.

88-K-1 Kingsley, L. C., Klesczewski, K. S., and Smith J. A., A Logistics Model of Coast Guard Buoy Tending Operations, *Proceedings of the Winter Simulation Conference*, Washington, DC, 1988.

88-P-1 Pietraszewski, D., Spalding, J., Viehweg, C, and Luft, L., U.S. Coast Guard Differential GPS Navigation Field Test Findings, *Navigation: Journal of the Institute of Navigation*, Vol. 31, No. 1, 55-72, 1988.

88-U-1 US Coast Guard, Office of Navigation Safety and Waterway Services, Chief, *WLB/WLM Replacement Sponsor's Requirements Documents*, Washington, DC, November 1988.

89-G-1 Gynther, J. W. and Smith, M. W., *Radio Aids to Navigation Requirements: the 1988 Simulator Experiment*, U.S. Coast Guard Research and Development Center, Groton, CT, November, 1989. (CG-D-08-90, NTIS AD-A226235)

89-T-1 Thacker, J.R., *Final Report on United States Coast Guard Aids to Navigation Servicing Trial Contracts*, Draft Report, USCG Headquarters, Washington, DC, October 1989.

90-D-1 Daidola, J. C., Basar, N. S., Johnson, F. M., and Walker, R. T., *Buoy Technology Survey USCG Buoy Development Review*, M. Rosenblatt & Son Inc., New York, NY, October 1990. (CG-D-04-92, R & D C 10/90, NTIS AD-A247183).

90-K-1 Kingsley, L. C., Klesczewski, K. S., and Smith J. A., *Comparing US Coast Guard Buoy Tender Performance Using Simulation*, Research and Development Center, Groton, CT, June 1990. (Draft report).

90-K-2 Krammes, S., and Crowell, R., *Demonstration of the Differential Global Positions System (DGPS) for Buoy Positioning*, United States Coast Guard Research and Development Center, October 1990.

90-L-1 Laxar, K., Luria, S. M. and Mandler, M. B., *A Comparison of Parallax and Single-Station Range Aids to Navigation: Final Report*, Naval Submarine Medical Research Laboratory, December 1990.

90-M-1 Mandler, M. B., and Smith M. W., Precision Electronic Navigation in Restricted Waterways, *Proceedings of the 46th Conference of the Institute of Navigation*, Atlantic City, NJ, June 1990.

90-R-1 Rosenblatt & Son, Inc., *Users Manual for the Buoy Technology Information System (BTIS)*, August 1990.

90-S-1 Smith, M.W., Mazurkiewicz, J., and Brown, W.K., *The Effect of Ship Inherent Controllability on Piloted Performance: The Simulator Experiment*, Ship Analytics, Inc., North Stonington, CT, October 1990. (CG-D-10-90, R&DC 16/90, NTIS AD-A228968).

90-T-1 Tung, F.F.C., Skaliotis, G.J., Goeddel, D., Flahive, D., and Cook, R., *Evaluation of Contracting the Servicing of Short Range Aids to Navigation*, Transportation Systems Center, Cambridge, MA, August 1990.

90-W-1 Wroblewski, M. R., and Mandler, M. B., *Detecting Buoy Lights: Effects of Motion and Lantern Divergence*, Research and Development Center, Groton, CT, March 1990 (CG-D-07-90, R&DC 05/90, NTIS AD-A225937).

91-D-1 Daidola, J. C., Basar, N. S., Reyling, C.J., and Walker, R. T., *Buoy Technology Survey Recommendations for Development of Buoy Technologies*, M. Rosenblatt & Son Inc., New York, NY, June 1991. (CG-D-06-92, R & D C 17/91).

91-D-2 Darby-Dowman, K., and Mitra, G., *Buoy Tendering - Inspection Timestamps A Prototype Model*, Brunel University, United Kingdom, September 1991.

91-M-1 Mazurkiewicz, J. and Smith, M.W., *The Effect of Ship Inherent Controllability on Piloted Performance: Evaluation and Prediction*, Interim Report, USCG Research and Development Center, Groton, CT, September 1991. (CG-D-10-93, R&DC 21/90).

91-S-1 Spalding, J., Krammes, S., and Pietraszewski, D., *Status of Prototype USCG DGPS Broadcasts from the Montauk Point, New York Radiobeacon*, US Coast Guard Research and Development Center, Groton, CT, March 1991.

91-V-1 Volpe National Transportation Systems Center, *Port Needs Study (Vessel Traffic Services Benefits) Study Overview*, Cambridge, MA, August 1991.

92-B-1 Brown, K. and Schwenk, J., *Aids to Navigation Service Force Mix 2000 Project: Project Overview*, John A. Volpe National Transportation Systems Center, Cambridge, MA, July 1992. (DOT-VNTSC-CG-92-2, DOT-CG-N-01-92-1.1).

92-B-2 Brown, K., Schwenk, J., Bucciarelli, M, and Jacobs, M., *Aids to Navigation Service Force Mix 2000 Project: Volume I Development and Application of an Aids to Navigation Service Force Mix Decision Support System - Final Report*, John A. Volpe National Transportation Systems Center, Cambridge, MA, July 1992. (DOT-VNTSC-CG-92-2.I, DOT-CG-N-01-92-1.2).

92-B-3 Brown, K., Schwenk, J., and Bucciarelli, M, *Aids to Navigation Service Force Mix 2000 Project: Volume II Development and Application of an Aids to Navigation Service Force Mix Decision Support System - Aid Assignments and Vessel Summary Reports*, John A. Volpe National Transportation Systems Center, Cambridge, MA, June 1992. (DOT-VNTSC-CG-92-2.II, DOT-CG-N-01-92-1.3).

92-C-1 Cline, A. K., King, D. H., and Meyering, J. M., Routing and Scheduling Coast Guard Buoy Tenders, *Interfaces*, Vol. 22, May-June, 56-72, 1992.

92-G-1 Grabowski, M. and Sanborn, S., Knowledge-Representation and Reasoning in a Real-Time Operational Control System: The Shipboard Piloting Expert System (SPES), *Decision Sciences*, Vol. 23, No. 6, 1277-1296, 1992.

92-I-1 Ihnat, D., *Aids to Navigation Service Force Mix 2000 Project: Volume III Analysis of Multi-Mission Requirements and Development of Planning Factors for the Replacement Buoy Tender Fleet*, Short Range Aids to Navigation Division, USCG Office of Navigation Safety and Waterway Services, Washington, DC, June 1992. (DOT-VNTSC-CG-92-2.III, DOT-CG-N-01-92-1.4).

92-M-1 MacRae, B.D., Stephenson, R., Leadholm, T., and Gonin, I., *Digital Chart Database Conversion into a System Electronic Navigational Chart*, USCG Research and Development Center, Groton, CT, March 1992. (CG-D-15-92, R&DC 04/92).

92-S-1 Smith, M.W., *Waterway Design Manual*, USCG Research and Development Center, Groton, CT, September 1992. (CG-D-18-92, R&DC 01/92, NTIS AD-A257030).

92-S-2 Smith, M. W., and Mandler, M. B., Human Factors Evaluations of Electronic Navigation Systems, *Proceedings of the First Annual Conference and Exposition for Electronic Chart Display and Information Systems: ECDIS '92*, Baltimore, MD, February 1992, 113-122.

92-S-3 Stewart, R. D., and Alexander, L., *Evaluation of Remote Vessel Tracking and Control: Preliminary Trials*, presented at the 1992 RTCM Annual Assembly Meeting, Bal Harbor, FL, 1992.

92-U-1 US Coast Guard, Office of Navigation Safety and Waterway Services, Chief, *Aids to Navigation Service Force Mix*, Washington, DC, February 1992.

93-A-1 Alexander L., and Spalding, J. W., *Integrated Marine Navigation Systems of the Future*, presented at the Institute of Navigation National Technical Meeting, San Francisco, CA, January 1993.

93-B-1 Brown, K., *Analysis of USCG Replacement Stern-Loading Buoy Boat Requirements for the Aids to Navigation Mission*, John A. Volpe National Transportation Systems Center, Cambridge, MA, August, 1993. (DOT-VNTSC-CG-569-TM-5).

93-B-2 Brown, K., Blythe, K., Schwenk J., and West, M., *Overview of the US Coast Guard Short Range Aids to Navigation Mission*, John A. Volpe National Transportation Systems Center, Cambridge, MA, 1993. (DOT-VNTSC-CG-93-2, DOT-CG-N-02-93).

93-G-1 Grabowski, M. and Wallace, W., An Expert System for Maritime Pilots: Its Design and Assessment using Gaming, *Management Science*, Vol. 39, No. 12, 1506-1520, 1993.

93-L-1 Lee, J.D. and Sanquist, T.F., *Human Factors Plan for Maritime Safety: Annotated Bibliography*, Battelle Human Affairs Research Centers, Seattle, WA, February 1993. (CG-D-08-93, R&DC 05/93, NTIS AD-A265392)

93-M-1 Murphy, J. M., *Buoy Maintenance Study Part I*, USCG Maintenance and Logistics Command, Atlantic, September 1993.

93-P-1 Polant, R.M., The Coast Guard--in the 21st Century, *The Bulletin*, USCG Academy Alumni Association, New London, CT, February 1993.

93-S-1 Spalding, J. W., Flynn, S., and van Diggelen, F., *Servicing and Positioning Aids-to-Navigation with DGPS*, Institute of Navigation GPS '93 Conference, Salt Lake City, UT, 1993.

94-B-1 Brown, K., Bucciarelli, M., and Leo, F., *Analysis of Fleet Size and Private Sector Cost Comparisons for the USCG Inland Construction Tender Fleet*, John A. Volpe National Transportation Systems Center, Cambridge, MA, May 1994. (DOT-VNTSC-CG-94-4, DOT-CG-N-01-94)

94-F-1 Fremont-Smith, R., *Study of Feasibility of Changing Minor Lights, Buoy and Daybeacon Servicing Intervals*, Short Range Aids to Navigation Division, USCG Headquarters, Washington, DC, June 1994.

94-F-2 Fremont-Smith, R., *United States Coast Guard Ocean Buoy Recapitalization Study*, Short Range Aids to Navigation Division, USCG Headquarters, Washington, DC, September 1994.

94-M-1 McLeish, D. B., and Alexander, L., *Buoy Tending with ECDIS: The Future is Now*, presented at the XIIIth IALA Conference, Honolulu, HI, February 1994.

94-S-1 Sanquist, T.F., Lee, J.D. and Rothblum, A.M., *Cognitive Analysis of Navigation Tasks: A Tool for Training Assessment and Equipment Design*, Battelle Human Affairs Research Centers, Seattle, WA, April 1994. (CG-D-19-94, R&DC 12/94, NTIS AD-A284392).

94-S-2 Smith, M. W., Akerstrom-Hoffman, R., Pizzariello, C. M, Siegel, S. I., and Gonin, I. M., Mariner's Use of Automated Navigation Systems, *Transportation Research Record 1464*, 1994.

94-S-3 Spalding, J. W., Flynn, S., Milne, W. and van Diggelen, F., *Interim Report on Servicing and Positioning Aids-to-Navigation with DGPS Incorporating Receiver Autonomous Integrity Monitoring*, United States Coast Guard Research and Development Center, April 1994.

94-U-1 US Coast Guard, Office of Engineering, Logistics and Development, and Office of Navigation Safety and Waterway Services, *Base/Support Center Industrial Support Roles Focus Group*, Washington, DC, 18 March 1994.

94-U-2 US Coast Guard, Short Range Aids to Navigation Division, Fleet Development Team, *Short Range Aids to Navigation Mission Analysis SRAMA*, Washington, DC, April 1994.

95-B-1 Brown, K., Corey, J., and Blythe, K., *Waterways Management Research and Planning Baseline Analyses: Waterways Management*, Volpe National Transportation Systems Center, Cambridge, MA, April 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-1).

95-B-2 Bucciarelli, M. and Brown, K., A Desktop-OR Success: Modeling Coast Guard Buoy Tender Operations, *Interfaces*, Vol. 25, No. 4, 1-11, July-August 1995.

95-C-1 Casey, L., Watros, G., and Hall, T., *Waterways Management Research and Planning Baseline Analyses: Navigational Risk Assessment*, Volpe National Transportation Systems Center, Cambridge, MA, April 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-3).

95-E-1 Ecker, W. J. and Alexander, L., The Impact of Emerging Technologies on Waterway Safety and Management, *The Bulletin*, USCG Academy, New London, CT, 27-31, August 1995. (Reprinted from *Sea Technology*, March 1995)

95-G-1 Grabowski, M. and Sanborn, S., *Shipboard Evaluation of the Shipboard Piloting Expert System (SPES)*, US Coast Guard Research and Development Center, Groton, CT, July 1995.

95-G-2 Grabowski, M. and Sanborn, S., Integration and Preliminary Shipboard Observations of an Embedded Piloting Expert System, *Marine Technology*, Vol. 32, No. 3, 216-223, July 1995.

95-L-1 LaMance, J., Spalding J. W., and Brown, A., *Boosting Shipboard RAIM Availability*, presented at ION Fall Meeting, Palm Springs, CA, September 1995.

95-L-2 Lunday, M. T., Spalding, J. W., and Dowd, M., *Verification of USCG DGPS Broadcast Parameters*, presented at the Institute of Navigation GPS '95 Conference, Palm Springs, CA, September 1995.

95-M-1 Murphy, J. M., *Buoy Maintenance Study Part II*, USCG Maintenance and Logistics Command, Atlantic, February 1995.

95-M-2 Maio, D., Nabrynski, J., and Long, D., *Waterways Management Research and Planning Baseline Analyses: Waterways Users*, Volpe National Transportation Systems Center, Cambridge, MA, April, 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-2).

95-M-3 Maio, D. and Watros, G., *Waterways Management Research and Planning Baseline Analyses: Project Overview*, Volpe National Transportation Systems Center, Cambridge, MA, April 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-5).

95-S-1 Smith, M. W., Akerstrom-Hoffman, R., Pizzariello, C. M, Siegel, S. I., Schreiber, T. E., and Gonin, I. M., *Human Factors Evaluation of Electronic Chart Display and Information Systems (ECDIS)*, Department of Transportation, United States Coast Guard Research and Development Center, February 1995. (CG-D-12-95, R&DC 10/93, MSI/CAORF 26-9038-01A, NTIS AD-A295524).

95-S-2 Spalding, J. W., and van Diggelen, F., *Positioning United Sates Aids-to-Navigation Around the World*, presented at the Institute of Navigation GPS '95 Conference, Palm Springs, CA, September 1995.

95-U-1 US Coast Guard, *Waterway Analysis and Management System Completion Guide*, Washington, DC, January 1995.

95-W-1 Winkeller, R., Watros, G., and Weber, A., *Waterways Management Research and Planning Baseline Analyses: Management Systems Effectiveness and Benefits Estimating*, Volpe National Transportation Systems Center, Cambridge, MA, April 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-4).

96-B-1 Brown, G. G., Dell, R. F., and Farmer, R. A., Scheduling Coast Guard District Cutters, *Interfaces*, Vol. 26, No. 2, 59-72, March-April, 1996.

96-G-1 Grabowski, M. and Georg, J. C., Integrated Bridge Systems Performance, Expert Systems and Human Performance, *Proceedings of the Public Forum on Integrated Bridge Systems*, National Transportation Safety Board, Tysons Corner, VA, March 1996.

96-G-2 Gonin, I., Dowd, M. K., and Alexander, L., *Electronic Chart Display and Information System (ECDIS) Test and Evaluation, Summary Report*, United States Coast Guard Research and Development Center, December 1996. (CG-D-20-97, R&DC 39/96, NTIS AD-A329592).

96-H-1 Heerlein, W., *A Catalog of Information Resources from a Waterways Management Perspective*, U.S. Coast Guard Research and Development Center, March 1996.

96-N-1 National Research Council, *Vessel Navigation and Traffic Services for Safe and Efficient Ports and Waterways, Interim Report*, Marine Board, NRC, Washington, DC, 1996.

96-S-1 Spalding, J. W., Lunday, M. T., and Dowd, M. K., *Differential Beacon Receiver Testing*, United States Coast Guard Research and Development Center, June 1996. (CG-D-24-96, R&DC 18/96, NTIS AD-A317835).

96-S-2 Spalding, J. W., and Crowell, R. D., *Performance Test Results of DGPS and DPS Testing on USCGC Juniper (WLB-201)*, United States Coast Guard Research and Development Center, September 1996.

96-V-1 Volpe National Transportation Systems Center, *Waterways Evaluation Tool Functional Requirements*, Initial Draft, Cambridge, MA, March 15, 1996.

96-V-2 Volpe National Transportation Systems Center, *Waterways User Groups Characterized According to the Navigational Requirements of the Vessel Operators*, Final Report, Cambridge, MA, August 1996.

97-C-1 Creamer, P. M., Cho, D. L., Morris, P. B., and Pisano, J. J., *Differential GPS Mission Needs Analysis: Harbor Entry and Approach*, TASC, Reading, MA, November 1997. (TIM-08605-1).

97-G-1 Gonin, I., and Crowell, R., *Assessing Electronic Chart Systems*, United States Coast Guard Research and Development Center, March 1997.

97-S-1 Spalding, J. W., and Alexander, L., *United States Coast Guard Integrated Ice Navigation System Research*, United States Coast Guard Research and Development Center, January 1997.

97-S-2 Spalding, J. W., and Crowell, R. D., *Performance Test Results of DGPS and DPS Testing on USCGC IDA LEWIS (WLM-551)*, United States Coast Guard Research and Development Center, July 1997.

97-U-1 US Department of Transportation/Department of Defense, *1996 Federal Radionavigation Plan*, Washington, DC, July 1997.

97-U-2 US General Accounting Office, *Coast Guard Challenges for Addressing Budget Constraints*, GAO/RCED-97-110, Washington, DC, May 1997.

98-R-1 Ryan, S., Petovello, M., and Lachapelle, G., Augmentation of GPS for Ship Navigation in Constricted Water Ways, *Proceedings of ION NTM 98*, Long Beach, CA, January 1998.

HISTORICAL SUMMARY OF AIDS TO NAVIGATION ANALYSES

APPENDIX B:

ANNOTATED BIBLIOGRAPHY OF REVIEWED AIDS TO NAVIGATION ANALYSES

This Appendix includes the Annotated Bibliography for those studies, papers, and analyses that have been reviewed and are included in this historical summary of aids to navigation analyses. In some cases, the abstract in the annotated bibliography is a verbatim abstract from the original source document as prepared by the author(s). In many instances, the abstract in the annotated bibliography starts with the original paper abstract and then includes additional information regarding the conduct on the analysis based on the current review. In some cases, a Note is added in brackets that comments on the approach taken in the analysis, frequently identifying unstated assumptions and cautions that should be observed regarding the results presented. The main body of this report, which the annotated bibliography supports, places the various analyses in context and further develops the strengths and limitations of the analysis reviewed.

The analyses included in the annotated bibliography are indexed using a notation that includes the year of publication, the first letter of the first author's last name, and a sequential number indicating the number of a publication in that year by authors whose last name begins with the same letter. In order to develop a chronological perspective of the historical development of these analyses, they have been arranged in chronological order by year of publication. The index is of the form YY-L-# where YY is the year of publication, L is the first letter of the first author's last name, and # is the sequential number appearing under that year and letter. An alphabetical list of references is included in the main portion of this report. Each reference in that listing for which an entry is included in the annotated bibliography is cross-referenced to this index number.

A full citation of each work is given, including the agency report number, the Coast Guard report number where appropriate, and the National Technical Information Service (NTIS) accession number (AD-Axxxxxx). Appropriate pages are given for publications that appeared in journals and proceedings. A number of analyses are internal Coast Guard studies and have limited availability.

Finally, each work is classified using the categories in the following table. The categories are somewhat general and a given work could often be identified as being in more than one primary classification. However, each work is given one primary classification and as many secondary classifications as seems appropriate. The evaluation of the studies from a category perspective is included in the main body (Volume I) of this report.

Table B1: Classification Table.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 67-U-1

Citation:

US Coast Guard, *Issue Paper--Coast Guard Buoy Tender Utilization*, Office of Operations Plans and Programs Staff, Washington, DC, 1967.

Abstract:

Following a 1966 General Accounting Office of buoy tender utilization in the First District, one WLB was reassigned to oceanographic duties, and the need for a Coast Guard wide review of buoy tender utilization was apparent. This Issue Paper was prepared by the Plans and Programs Staff of the Office of Operations, external to the Aids to Navigation Division during the Administrative General Quarters that followed the transfer of the Coast Guard to the new Department of Transportation. This issue paper focused on the improving utilization of the buoy tender fleet following efforts to improve reliability and extend service intervals. In 1966, electric lights had been replacing acetylene and hardware reliability was sufficient to support semi-annual visits, although fleet size was designed for quarterly visits. The issue paper focused on an operating target of 1600 to 200 hours and recommended elimination of several older resources no longer needed because of the extended servicing interval. The paper suggested replacing some WLIs with a more capable 46' BUSL. Overall, the issue paper recommended a reduction of 4 WLBs and 6 WLIs with an increase in 8 buoy boats. The issue paper concluded that a full system study was in order, but recommended implementing the suggested changes to take immediate advantage of obvious efficiencies.

[Note: Abstracted from a description of the issue paper in SRAMA (US Coast Guard, 1994) and Armacost, 1977]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 69-G-1

Citation:
Gathy, B. S., and Danahay, P. J. *A Study of the Western Rivers Aids to Navigation System*, USCG Academy, New London, CT, December, 1969.

Abstract:
This report covers a study of the western river aids to navigation operations for FY68. The objective of the study was to provide a baseline for comparing the existing system with any alternate system or system component. The report includes operating costs, commercial usage, and other pertinent data for the rivers.

[Note: Report not reviewed. Abstract developed from Armacost, 1977.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 69-G-2

Citation:
Geonautics, Inc., *Study of Maritime Aids to Navigation in the Short Distance Maritime Environment*, Falls Church, VA, 1969. (Contract DOT-CG-83291-A)

Abstract:
This study attempted to identify various systems of aids that would satisfy the users of ATON systems. The report included a benefit methodology that was developed at a very general level to measure the value of the existing system and the value of an "improved" system.

[Note: Report reviewed in Armacost, 1977.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 70-B-1

Citation:

Booz-Allen Applied Research Inc., *Evaluation of Plastic Versus Steel for Buoy Hulls*, Washington, DC, January, 1970a.

Abstract:

The Booz-Allen (BA) Study included three tasks: (1) evaluation of plastics versus currently used buoy materials; (2) evaluation of the use of buoys versus fixed structures; and (3) evaluation of alternative maintenance and servicing facilities. The contract included an estimated 9040 manhours of work. The focus of the study was a life-cycle cost evaluation of the alternatives in each task. BA was also tasked with developing a time-phased implementation plan for any recommended changes.

Environment	Number of buoys (1970)
Exposed	
Lighted	1600
Unlighted	1400
Protected/Semi-exposed	
Lighted	1800
Unlighted	9100
Fresh water with ice	
Lighted	700
Unlighted	2000
River	
Lighted	100
Unlighted	9400
TOTAL BUOYS	26,000
Structures	18,000
TOTAL AIDS	44,000

The Task 1 BA evaluation of plastic buoys showed that they were technically feasible in all environments. Under the then current servicing schedule, there would be some savings in exposed and protected/semi-exposed environments. The total cost savings was estimated at 2% (approximately $700,000). Changing the servicing schedule and relief period resulted a 16% savings for steel buoys and a 17% savings for plastic buoys. The cost savings for plastic over steel under a revised servicing schedule was approximately $200,000. BA then considered changes to the servicing vessels and used smaller vessels where possible. Under this scenario, an additional 8% savings was realized for steel buoys (22% total), and an additional 11% savings realized for plastic buoys (28% total). The cost advantage of plastic over steel was now $1.5 million. Based on these results, BA recommended the use of plastic buoys (along with Task 3 servicing improvements).

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics	☑	Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 70-B-2

Citation:

Booz-Allen Applied Research Inc., *Evaluation of Minor Marine Structures Versus Buoys*, Washington, DC, May, 1970b.

Abstract:

The Booz-Allen (BA) Study included three tasks: (1) evaluation of plastics versus currently used buoy materials; (2) evaluation of the use of buoys versus fixed structures; and (3) evaluation of alternative maintenance and servicing facilities. The contract included an estimated 9040 manhours of work. The focus of the study was a life-cycle cost evaluation of the alternatives in each task. BA was also tasked with developing a time-phased implementation plan for any recommended changes.

Environment	Number of buoys (1970)
Exposed	
Lighted	1600
Unlighted	1400
Protected/Semi-exposed	
Lighted	1800
Unlighted	9100
Fresh water with ice	
Lighted	700
Unlighted	2000
River	
Lighted	100
Unlighted	9400
TOTAL BUOYS	26,000
Structures	18,000
TOTAL AIDS	44,000

The Task 2 BA evaluation of replacing buoys with structures considered approximately 5100 buoys (300 lighted and 4800 unlighted) that were in protected/semi-exposed environments and in 20 feet or less of water. BA observed that because structures are more effective aids to mariners than buoys, replacement could be on a better than one-to-one basis. In addition, structures could be serviced by smaller vessels and on a slightly reduced schedule than buoys. BA concluded that life-cycle costs of structures and buoy systems were comparable when the servicing vessels are comparable, but that significant cost savings could be realized if improved servicing schedules were used for both buoys and structures. BA estimated annual savings of $10 million by the combined use of structures, plastic buoys, improved servicing schedules, and smaller servicing vessels.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings	☑	Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics	☑	Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 70-B-3

Citation:
Booz-Allen Applied Research Inc., *Servicing Systems for Short-Range Aids to Navigation*, Washington, DC, November, 1970c.

Abstract:
The Booz-Allen (BA) Study included three tasks: (1) evaluation of plastics versus currently used buoy materials; (2) evaluation of the use of buoys versus fixed structures; and (3) evaluation of alternative maintenance and servicing facilities. The contract included an estimated 9040 manhours of work. The focus of the study was a life-cycle cost evaluation of the alternatives in each task. BA was also tasked with developing a time-phased implementation plan for any recommended changes.

Environment	Number of buoys (1970)
Exposed	
Lighted	1600
Unlighted	1400
Protected/Semi-exposed	
Lighted	1800
Unlighted	9100
Fresh water with ice	
Lighted	700
Unlighted	2000
River	
Lighted	100
Unlighted	9400
TOTAL BUOYS	26,000
Structures	18,000
TOTAL AIDS	44,000

The Task 3 BA recommendations included a number of elements that resulted in a revised service force mix. The recommendations included the recommendations from Tasks 1 and 2 that called for increased use of plastic buoys and converting about 5100 buoys to structures. A key recommendation involved reducing the servicing frequency for all types of aids, and assigning dual responsibility for aid maintenance. A new service element was proposed: the Aids to Navigation Team (ANT) that would be equipped with special Aids to Navigation Boats (ANB) or trailerable ANBs (TANB). BA identified a complete mix of shore facilities that would be required to support the servicing effort. The major cost reduction came with reducing the number of offshore and inshore buoy tenders. BA suggested two reduced service schedules. Under the 1971 servicing policy, WLBs made an average of 3.3 visits per year for scheduled checks (1.0) and service (2.0) as well as unscheduled service (0.3). Under alternative 2, an ANT would be responsible for the scheduled check (1.0) and unscheduled service (0.3) and the OBT would be responsible for the scheduled service (1.0). Under Alternative 3, the scheduled check goes to 0.5 visits per year and the scheduled service goes to 0.5 visits per year. There were 38 WLBs (Alternative 1) in 1971 and a total of 45 would be required in 1985 given the projected aid growth. For the projected 1985 aid population, under Alternative 2, the total requirement was reduced to 24 and under

Alternative 3, the OBT requirement was reduced to 17. Similar analyses reduced the 1971 WLM/WLI requirement from 38 (46 in 1985) to 22 (Alternative 2 servicing) or 18 (Alternative 1 servicing). The construction tenders remained constant at 10. The river tenders were reduced from 25 (29 in 1985) to 9 (Alternative 2) or 6 (Alternative 3). River ANTS were used extensively to supplement the river tenders. The life-cycle operating cost analyses showed reduction of 30 to 40% over Alternative 1. The new servicing alternative required capital investment to establish the ANT facilities and boats as well as conduct a modernization and acquisition program for new tenders. The analysis concluded that the cumulative operating costs savings over the next few years would be equal to twice the amount needed to construct all of the vessels for the proposed system. BA emphasized the need for an accurate and up to date SANDS system for system management.

The BA analysis was comprehensive in examining all aspects of the ATON operating system. The BA final report documents the numbers of units and the service policies that are recommended. However, it does not document what type of analysis was used to determine how many buoy tenders of each type were required in each district. It appears that some assumptions were made about the length of coastline that could be assigned, along with aid density and some estimates of service time and enroute times for given ship speeds. A simple deterministic model was probably used to estimate the maximum coastline/density combination that could be serviced within given workload parameters.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings	☑	Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics	☑	Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 71-C-1

Citation:

Cohen, A., Steinberg, H. and Schofer, R., *An Initial Investigation of Economic Benefits of Maritime Aids of Short Range Navigation in Ports and Waterways*, National Bureau of Standards Report 10532, Washington, DC, 1971.

Abstract:

This study adapted the benefit methodology developed by Geonautics, Inc. and applied it to evaluate existing and improved ATON systems in 43 US ports and waterways.

[Note: Abstract developed from Armacost, 1977.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
☑	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 71-C-2

Citation:
Coyle, J. B., *Personnel Considerations for the Coast Guard's Aids to Navigation Program*, Aids to Navigation Division (OAN), USCG Headquarters, Washington, DC, 1971.

Abstract:
This study addressed personnel requirement for aids to navigation in detail. A previous 1969 study completed by Systems Development Corporation sponsored by the Office of Personnel identified training requirements for ATON that were considerably in excess of available resources. One of the keys to successful implementation of the Booz Allen recommendations was training of personnel, particularly since more responsibility for aid maintenance was being moved down to smaller units (ANTs) with fewer experienced personnel. The current study noted that the dispersion of personnel using ANTs actually mandated an increase in ATON trained personnel over that required using buoy tenders prior to ANT implementation.

[Note: Abstract developed from Armacost, 1977.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
☑	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 72-B-1

Citation:
Bates, R., *Channel Lighted Buoy Model,* Field Testing and Development Center, Baltimore, MD, March 1972. (Report No. 529).

Abstract:
The report describes the Channel Lighted Buoy Model (CLBM), a physical model that was developed to present, in small scale, the appearance of lighted buoys as seen by a mariner navigating the channel. The report includes the technical assistance rendered and acceptance tests conducted in conjunction with the development of the CLBM. A demonstration of the model's operating characteristics for Coast Guard Headquarters personnel is also discussed along with recommendations for future research with the CLBM. This model represents the Coast Guard's first attempt to capture the cognitive and perceptual impact of various aid configurations that could be used for evaluating alternatives.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 72-M-1

Citation:

McIntosh, J. A., *Follow-the-Wire Marine Aid to Navigation System: Report on an Initial Demonstration Installation*, Commandant(DAS), USCG Headquarters, Washington, DC, May, 1972.

Abstract:

A need exists for a short range, high accuracy marine navigation system for use in ice-covered rivers and channels. This report describes the evaluation of a system that uses an energized cable laid on a channel bottom precisely on the desired trackline, and sensing coils and display equipment mounted on the ship to determine and indicate the direction of the cable from the ship. This experiment was conducted in the Muskegon channel connecting Lake Michigan and Lake Muskegon using CGC WOODBINE. The five mile long cable was energized by a 400 Hz motor generator set. The circuit was completed using a ground return. The system proved to be reliable, accurate, repeatable, inexpensive and easy to use.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 72-U-1

Citation:
US Coast Guard , *Analysis to Define Present and Future Requirements for Inland Construction Tenders*, Aids to Navigation Division (WAN-5), Washington, DC, 1972.

Abstract:
This internal study immediately followed completion of the Booz-Allen Study. It defined the workload expected for inland construction tenders in the 1980 time frame and identified new resources required to replace obsolete tenders and provide the additional capability required. It identified a construction requirement for ten WLICs. The construction program was approved for eight WLICs developed along the lines of a Specific Operational Requirement (SOR) prepared by the Eight District. The original plan was based on a pusher-barge combination, but changes in expected operational deployment led to a single unit 160' design.

[Note: Abstract developed from Armacost, 1977.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology	☑	Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 74-B-1

Citation:

Bates, R., *Preliminary Investigation of Temporal and Chromatic Methods of Marking Channels,* USCG Research and Development Center, Groton, CT, April 1974. (CG-D-96-74, CG R&DC 11/74).

Abstract:

This report summarizes the results of initial research to determine the best methods for marking straight lighted channels. Two methods were examined: regulated time flashing (temporal) and color flashing (chromatic). In the temporal method, all (30) test observers chose the ordered systems (sequential and simultaneous) superior to the unordered systems (random, random-sequential, and random-simultaneous). Within the test conditions for ordered systems, sequential flashing was chosen best. In the chromatic method, a two color combination for channel marking was chosen best: a white-red system against a lighted background, and a green-red or white-red system against a dark background. This preliminary work shows an advantage to ordered temporal systems of marking channels as well as the advantage of the two color system.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 76-A-1

Citation:

Associated Controls & Communications, Inc., *Operational Report of a Precise Navigation System Modified and Tested to Demonstrate Feasibility for Dredging, Channel Sweeping and Buoy Tending Operations*, Lynn, MA, December 1976. (00288).

Abstract:

A passive reflector positioning system was installed aboard the US Corps of Engineers powered barge, SALEM. The evaluation was conducted under conditions which simulated the operation of a hopper dredge, as well as those of buoy tending and channel sweeping vessels. Operations were observed under a variety of weather and sea conditions. Accuracy and repeatability tests were performed during this period. Tests were performed in a test range in the Boston Harbor area (Nantasket Roads between Peddocks Island and Rainsford Island).

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 76-U-1

Citation:
US Coast Guard, *Determination of Construction Tender Requirements*, Aids to Navigation Division (WAN-5), Washington, DC, 1976.

Abstract:
Escalating construction costs for the 160' WLIC coupled with lower than expected utilization as reflected in operating statistics let to a reevaluation of the program. This study identified a need for six of the original eight construction tenders approved in 1972. Using additional information about the material condition of some of the vessels to be replaced, it was decided to halt the new construction program at four 160' WLICs and to "improve" two 100' WLIs that use construction barges.

[Note: Abstract developed from Armacost, 1977.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 77-A-1

Citation:

Armacost, R. L., *Good Intentions about Long Rang Planning for Short Range Aids to Navigation*, USCG Headquarters Aids to Navigation Division, Washington, DC, February, 1997.

Abstract:

This report represents a comprehensive review of all CG Aids to Navigation analyses (exclusive of hardware developments) that had been conducted through 1976. The report noted that no evaluation of the changes that had been implemented following the Booz Allen study had been conducted and that some of the BA recommendation had yet to be implemented. The report develops a long range planning effort that included the following categories of work: inventory/evaluation of hardware, personnel, costs; determination of service force levels/mix; personnel issues; operational management; operational aid system design; and operational plans. The report formed the basis for a number of internal studies and the large study on aid system design subsequently monitored by the R&D Center.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning	☑	Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
☑	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics	☑	Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 77-E-1

Citation:

Engelhard Minerals and Chemicals Corporation, *Fuel Cell Batteries for Operation of Aids to Navigation,* Research and Development Center, Groton, CT, October 1977. (CG-D-83-77, CGR&DC 30/77).

Abstract:

The report discusses a program for the development of air-breathing fuel cell batteries for the operation of aids to navigation. Calcium hydride is used as a fuel. The fuel cell batteries provide a significantly higher energy density than conventional power sources. The development focuses on battery systems suitable for USCG requirements. Modules with a capacity of 6 KWH and a nominal rating or 2 watts at 13 volts are being developed. Testing of single cells and battery modules is performed mostly with a USCG flasher using a 1.15A lamp. This program is the first step towards the development of hydride-based fuel cell batteries for use with aids to navigation. The development work has confirmed the suitability of the hydride cell for the design of high energy density batteries.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 77-G-1

Citation:

Giovane, F., *A Study of Aerial Semi- Precise Survey Systems for Position Auditing of Coast Guard Aids to Navigation,* Research and Development Center, Groton, CT, October 1977. (CG-D-61-77, CGR&DC 25/77).

Abstract:

This study evaluated aerial imaging systems capable of establishing the positions of aids to navigation to within 30 meters within 48 hours following adverse weather conditions such as ice or storm. A scenario area (400 km by 3 km) was created to simulate a region affected by such environmental conditions. The study considered aerial photographs, side-looking airborne radar, and visual observations from aircraft. It was concluded that there are no systems currently available to the Coast Guard to achieve aerial semi-precise survey of aids to navigation.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 77-G-2

Citation:

Giovane, F., *A Feasibility Study of Aerial Imaging Techniques for Precise Aids to Navigation Position Determination,* Research and Development Center, Groton, CT, December 1977. (CG-D-87-77, CGR&DC 33/77).

Abstract:

An investigation of the feasibility of using aerial imaging techniques for verifying precisely the positions of aids to navigation was conducted. It was determined that such a method is technically feasible using cartographic aerial photography and precise photogrammetric data reduction. However, such a system would be impractical and expensive for Coast Guard use on a routine basis.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 78-A-1

Citation:

Armacost, R.L. Status of Aids to Navigation and Deep Draft Navigation Channels: Coast Guard--Corps of Engineers Interaction, presented at the Deep Draft Navigation Channel Design Conference, Waterways Experiment Station, Vicksburg, MS, May 18, 1978.

Abstract:

This paper reviews the various levels of interaction between the Corps of Engineers and the Coast Guard regarding channel design, and identifies potential interactions involving aids to navigation and channel design that could result in improved navigational safety. Specifically, the Coast Guard provides input for waterways projects regarding aids to navigation maintenance/operating costs. However, this does not include an evaluation of the proposed aid configurations. Generally speaking, most projects submitted to the Coast Guard by the Corps already have aids located. Occasionally, the Coast Guard will make adjustments, but primarily provide cost data for the aids proposed by the Corps. Another area of interdependence without interaction is in the area of private aids to navigation. Users must obtain permits from both the Coast Guard and the Corps. The anticipated Nationwide Permit will soon eliminate this duplicate requirement. Aid positioning can benefit by making use of Corps reference marks used for dredging operations. The paper describes the Aids to Navigation Positioning Project (ANPP) that is developing improved procedures for the use of horizontal sextant angles for positioning, including the use of gradient charts. It also describes the R&D tasks to support aid positioning that are included in the *RDT&E Plan for Marine Safety*. The paper includes a good description of the research being conducted on Aids to Navigation System Performance. The competitive Phase I research effort involving Eclectech Associates, Science Applications, Inc., and Systems Control, Inc. is described including the initial results from all three contractors who developed models of the mariner/pilot and the process of obtaining position information that were included in a fast-time simulation. All three approaches were satisfactory and all are submitting Phase II proposals. Finally, the paper describes the CAORF research and the Phase IIIA Restricted Waterways Experiment that the Coast Guard partnered in to obtain better information about how aids to navigation are actually used. Included in this experiment were alternative channel configurations (e.g., cut-off corners in turns) that were also evaluated.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning	☑	Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
☑	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 78-B-1

Citation:

Bauman, F.S., Waelbrock, B.J., and Giovane, F., *Feasibility Study on the Capability for Visually Auditing Buoy Positions using VTS Radar and/or Low Light Level Television*, USCG Research and Development Center, Groton, CT, July, 1978. (CG-D-45-78, CGR&DC 31/77, NTIS AD-A059755)

Abstract:

This study examines the possibility of using VTS radar and/or Low Light Level Television (LLLTV) to conduct visual audits of buoy positions in a Vessel Traffic Service area. Buoy position audit using LLLTV does not appear feasible. Only general aid condition information is available. LLLTV does not produce adequate position information. Buoy position visual auditing using VTS radar could be feasible if certain improvements are made in the information display and interpretation areas. Coast Guard VTS units do not presently have the resources to conduct an aggressive, accurate visual buoy position audit program.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 78-C-1

Citation:
Clark, W.H., Stephenson, A.R., Bateson, R.H., Jones, J.E., Pohle, C.G., Kessler, K.M., and Sorenson, J., *Study of the Performance of Aids to Navigation Systems-- Phase I, Closed Loop Model of the Process of Navigation*, Systems Control, Inc., Palo Alto, CA, March, 1978. (CG-D-38-78, NTIS AD-A059891)

Abstract:
This Phase I study is one of three conducted in a competition to develop a methodology for evaluating and improving aids to navigation systems in the harbor and harbor entrance environment. Although the performing organization (Systems Control, Inc.) did not receive the Phase II contract, the Phase I study includes significant results. The report includes a comprehensive state of the art review of work that had been done to model aids to navigation systems. This included an evaluation of the literature, facilities, and interviews with numerous experts and users. They concluded that the ongoing effort was the state of the art, and that no one had attempted to model the role of aids to navigation in vessel operations to date. As part of the study, the essential elements of the process of navigation were identified and were incorporated in a functioning model of the process of navigation. The model was incorporated in a fast time simulation and the model results were validated against recent man-in-the-loop simulations at the Computer Aided Operations Research Facility (CAORF), the only real time ship simulator available for research. The model was used to successfully emulate mariner/vessel performance in real world conditions. The mariner's requirements for navigational information available from aids was identified and correlated with information utilization associated with unique vessel, environmental, and visual aids to navigation system characteristics. The form and structure of a preliminary Navigation System Evaluation Model were developed, and the requirements for model completion and validation were defined.

The prototype simulation model was developed to demonstrate the validity of the approach. It was not a deliverable for the project. It would have been a primary deliverable for the Phase II effort. Nonetheless, the report contains significant detail on how the navigation processes were modeled.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 78-C-2

Citation:

Couchman, R. L., *An Overview of Alternative Techniques for Determining Positions at Sea, with Emphasis on Applicability of Potential Use for Positioning Buoys*, Research and Development Center, Groton, CT, March 1978. (CG-D-20-78, CGR&DC 5/78, NTIS AD-A061997).

Abstract:

This report catalogs and evaluates various field survey techniques of position determination, whether presently in use or in development, with particular emphasis on the general capabilities, limitations, and application of the individual techniques for use in positioning buoys. The results of the evaluation indicate that no single method can be used to satisfy the varied buoy placement scenarios. Instead, a combination of methods (including those presently used) would be most appropriate. Furthermore, no single combined-methods system would fit all applications unless it consisted of an all-encompassing set of equipments and procedures; an impractical solution. Laser rangefinder, precision gyrocompass, radiodetermination, and satellite methods are considered to have applicability to buoy placement operations, either as stand-alone or for incorporation with a multi-sensor system. Inertial guidance and underwater acoustic methods are not considered to have practical application.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 78-G-1

Citation:

Grossetti, M., Prime, K., Campbell, M., and Moukawsher, E.J., *Buoy Reference Library,* Research and Development Center, Groton, CT, March 1978. (G-D-50-78, CGR&DC 6/78, NTIS AD-A076309).

Abstract:

This report is the initial attempt to develop a buoy reference library. The report contains references to books and papers as well as a list of buoy manufacturers. The reports are arranged in seven categories: (1) mooring systems, (2) power sources, (3) development and design, (4) applications and uses, (5) instrumentation, math and computer models, (6) characteristics, and (7) miscellaneous. Fixed and floating breakwaters were addressed separately.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 79-B-1

Citation:

Bertsche, W.R. and Cook, R.C., *Analysis of Visual Navigational Variables and Interactions*, Eclectech Associates, Inc., North Stonington, CT, October, 1979.

Abstract:

This interim report documents the description of the variables that will be used in the CAORF and Eclectech simulators in Phase II of the Aids to Navigation project. The report describes the variables relevant to the design of aids to navigation systems in restricted waterways. These variables are discussed as a step in the process of developing analytical techniques for the design and evaluation of aids to navigation systems. The focus is on variables known or suspected to affect visual navigational performance in narrow channels and turns typical of harbor waterways. The variables selected describe ship characteristics, physical dimensions, and characteristics of channels and turns, environmental conditions and characteristics or properties of aids to navigation. The approach identified the physical constraints on the variables, the relative magnitude of their effect, and the range and distribution of the variables in the real world.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 79-D-1

Citation:

Debok, D. H., and Walker, R. T., *Analysis of "Offstation" Buoys*, Research and Development Center, Groton, CT, May 1979. (CG-D-67-79, USCG R&DC 20/79).

Abstract:

This study reviews 51 months of Coast Guard records for buoys exhibiting inadequate anchor reliability. Two types of low reliability are considered: (1) buoy stations with lower than average anchor reliability (repeat offenders); and (2) stations for which average reliability is inadequate (critical buoys) Initially, failure rate is determined using a failure rate diagram and then applied to identify buoy stations with below average anchor reliability. Classification of buoy station characteristics and causes of failure are provided for reported anchor failures.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 79-L-1

Citation:
Lozano-Perez, T., and Wesley, M. A., An Algorithm for Planning Collision-Free Paths Among Polyhedral Obstacles, *Communications of the ACM*, Vol. 22, No. 10, 560-570, October, 1979.

Abstract:
This paper describes a collision avoidance algorithm for planning a safe path for a polyhedral object moving among known polyhedral objects. The algorithm is used in the route planning model by Cline and King that is incorporated in the ANGEL simulation model.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 80-C-1

Citation:

Cooper, R. B., and Marino, K. L., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays - the Mini-experiment*, Eclectech Associates, North Stonington, CT, September 1980. (CG-D-59-80, EA-80-U-88).

Abstract:

This report describes a simulator evaluation of electronic radio aids to navigation displays conducted for the purpose of trading off display information effectiveness with operational requirements and shipboard cost. The miniexperiment, a predecessor to more lengthy experimentation, used an abbreviated scenario involving a 30 degree bend in a channel to operationally simulate 18 display formats. Six digital, ten graphic, and two perspective displays were evaluated. The digital display was designed to provide trackkeeping and turning information that would enable pilot to transit the waterway while using an inexpensive digital (alphanumeric or numeric only) display. The graphic display was designed to provide a pictorial representation of ownship in the waterway similar to the way it is viewed on radar, contemporary collision avoidance, or navigation option displays. The perspective display was designed to portray the perspective scene as viewed out of the forward bridge windows. Overall, the results suggest that the graphic display is the best. The perspective display results appear to have been affected by the lack of 90 degree view (abeam)--the experiment only provided 60 degree view. Various options using the different display types yielded different performance results. Based on the results, seven specific displays were recommended for further examination in the RA-1 experiment.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
☑	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 80-M-1

Citation:

Millbach, M. A., *Error Sensitivity Model - Second Interim Report,* Research and Development Center, Groton, CT, April 1980. (CG-D-53-80, R&DC 8/80, NTIS AD-A089277).

Abstract:

This report describe a computer model written to simulate errors associated with the Coast Guard aids to navigation positioning process with emphasis placed on finding average effects of errors in the system. A mathematical expectation approach was used to model random system elements. The model routines have been designed to study specific positioning situations, or, by use of Monte Carlo methods, a variety of situations as a group. The model was designed for use in planning within the aid positioning macrostructure. For planning purposes, the probability that the resulting position lies within a specific circular region is a meaningful measure of positioning success.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 81-C-1

Citation:

Cook, R. C., Marino, K. L, and Cooper, R. B., *A Simulator Study of Deepwater Port Shiphandling and Navigation Problems in Poor Visibility*, Eclectech Associates, North Stonington, CT, January 1981. (CG-D-66-80, EA-80-U-099).

Abstract:

This study used a ship's bridge simulator to examine navigation issues, effect of navigation displays, and the effect of bridge personnel organization during low visibility approaches of a VLCC to a deepwater port complex. Ninety simulated approaches were made with radar, radar with added racons, an automatic radar plotting aid (ARPA), or an ARPA displaying fairway boundary lines. Experienced masters and mates were used in making a landfall, a coastwise approach, approach to pick up a mooring master, and a dead reckoning approach with degraded position information. Study recommendations included relocating the mooring master pickup point, providing an anchorage to be used when waiting for a mooring master, placement and implementation of racons, and the use of special bridge procedures and navigation systems. The study concluded that approaches of VLCCs to deepwater ports are not deceptively difficult or inherently unsafe. There are some opportunities to mitigate the potential for hazardous navigation and shiphandling problems.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 81-C-2

Citation:

Cooper, R. B., Marino, K. L., and Bertsche, W. R., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays, the RA-1 Experiment*, Eclectech Associates, North Stonington, CT, January, 1981a. (CG-D-49-81, EA-80-U-086).

Abstract:

This report describes a ship's bridge simulation of electronic radio aids to navigation displays conducted to compare digital, graphic, perspective, and steering display formats. Five displays recommended from the miniexperiment with two new steering displays were used. A total of 52 45-minute scenarios were executed to compare the effectiveness of the displays. The basic conclusion is that a true motion trackup graphic display with either course or heading vectors is recommended as a benchmark for future experimentation. The current experiment was conducted with perfect position information. The follow-up experiment will consider ownship position error. The Predictor Steering Display provided the best overall performance, but the subjects' perceived it as being too sophisticated to be cost effective or reliable.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
☑	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 81-C-3

Citation:

Cooper, R. B., Marino, K. L., and Bertsche, W. R., *Simulator Evaluation of Electronic Radio Aids to Navigation Displays, the RA-2 Experiment*, Eclectech Associates, North Stonington, CT, April, 1981b. (CG-D-509-81, EA-81-U-009).

Abstract:

This report describes a ship's bridge evaluation of an electronic radio aids to navigation display for use by pilots in restricted waterways. The report includes a review of the previous experimentation (miniexperiment and RA-1) leading up to the current study (RA-2). This study used a "benchmark" true motion, trackup graphic display recommended in the RA-1 experiment to conduct simulated poor visibility runs of a 30,000 dwt tanker around a 35-degree left bend in a 500 foot wide channel. The display used a heading vector and a scaled image of ownship. Experimental variables included two different navigation system noise levels which translated to random position errors of 16 and 32 meters RMS, and the use of an ALPHA-BETA tracker with 3-, 12- or 24-second rise time, or gyro aiding to represent a state-of-the-art navigation system filter capability. Evaluation criteria included pilot trackkeeping and maneuvering performance as well as system acceptance. The simulation included 64 35-minute runs using experienced pilots.

The simulation with noise and the characteristics of an actual navigation system uncovered a previously unaddressed problem: the effects on pilotage of display lag and jitter. Jitter or "jumping around" results from random position errors in the navigation system. Mathematical tracker filters smooth out the jitter, but cause a display lag. Jitter and display lag are inversely related. Consequently, the pilot never knows the real position of the ship. The main effect is that the displayed image reacts differently to maneuvering actions than does the real ship and actual performance is degraded. In this experiment, the use of electronic radio aids to navigation display alone never achieved trackkeeping or maneuvering performance comparable to those simulations where pilots could view out the windows. The report identifies various combinations of noise and tracker rise-times that are acceptable. Gyro-aiding reduces the adverse effects of jitter and lag.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
☑	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 81-C-4

Citation:

Cooper, R. B., and Bertsche, W. R., *An At-Sea Experiment for the Comparative Evaluation of Radar Piloting Techniques*, Eclectech Associates, North Stonington, CT, November 1981. (EA-81-U-066).

Abstract:

This report describes the second of two at-sea evaluations to determine the effectiveness of various fixed, floating, and electronic aids to navigation on harbor pilotage. Using two licensed pilots, USCGC RED BIRCH made 52 transits of straight channel legs in upper Chesapeake Bay. Four different pilotage techniques were used: visual ranges, traditional radar piloting, radar course piloting using a RACON, and piloting using the Sperry CAS II PATH display. The experiment used pilot's accuracy of judging their position within the channel as a primary measure for comparing the effectiveness of the piloting techniques. Actual ship position was measured using a LORAN C tracking system developed by the Coast Guard R&D Center. Results indicated that visual pilotage produced the best performance and that traditional radar pilotage was substantially poorer. The effectiveness of course cursor piloting on RACONS showed promise as a valuable technique provided that some of its implementation problems can be overcome. Use of the PATH display for pilotage proved only as effective as radar, but there were indications that additional experience by the pilots would have substantially improved their performance. Recommendations are included both for improving the design of equipment and for further development of piloting techniques associated with the hardware.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 82-D-1

Citation:

Drijfhout van Hooff, J. F., *Aids to Marine Navigation*, Volume II, Maritime Research Institute Netherlands, Report number R-238, June 1982.

Abstract:

This manual provides a comprehensive description of the process of visual navigation and the design and use of aids to navigation systems. It provides a sound guide for the design of channels and associated marking systems.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 83-M-1

Citation:

Multer, J., and Smith, M.W., *Aids to Navigation Turn Lights Principal Findings: Effect of Turn Lighting Characteristics, Buoy Arrangement, and Ship Size on Nighttime Piloting,* Eclectech Associates, Inc., North Stonington, CT, February, 1983 (CG-D-49-82, EA-82-U-054, NTIS AD-A126080).

Abstract:

This report documents one of the simulator experiments in the Performance of Aids to Navigation Program. It provides quantitative data on piloting performance in narrow channels with turns. This experiment investigates the effects of buoy lighting characteristics in the turn on nighttime piloting. Day/night differences were found in the use of strategies to maneuver through the turn, with the daytime track more gradual. Of the flash rates, quick flash supported performance most like daytime. The need for quick flash is most critical at the turn point, or inside apex buoy. Synchrony of turn buoys did not meaningfully contribute to performance. A three-buoy turn arrangement supported better turn performance than a two-buoy arrangement, a difference that was more critical for the larger ship size. (Includes references to predecessor studies.)

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 83-M-2

Citation:

Multer, J. and Smith, M. W., *Aids to Navigation Radar I, Principal Findings: Performance in Limited Visibility of Short Range Aids with Passive Reflectors*, Eclectech Associates, Inc., North Stonington, CT, December 1983. (CG-D-79-83, 83-U-143, NTIS AD-A137596).

Abstract:

This report documents one of the simulator experiments in the Performance of Aids to Navigation Program. The experiment evaluates the efficacy of floating aids (buoys) equipped with passive reflectors and the use of radar (3 cm) in limited visibility. Comparisons were made to piloting in adequate visibility without radar. Differences in performance were most evident in the turn region while differences in trackkeeping regions were less noticeable. In the turn region, performance suffered more in the low visibility conditions with radar than in the adequate visibility conditions without radar. Performance in the radar piloting scenarios was also worse in the lowest visibility condition in the turn. Pilots performed better with smaller ship and aid arrangements having higher density spacing. Finally, style differences in the use of radar were found and related to differences in ship track performance. (Includes references to predecessor studies.)

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 83-R-1

Citation:
Reik, J. R. and Hargis, S. C., *Coastal Risk Management*, 5th CAORF Symposium, 1983, B2-1 - B2-12.

Abstract:
This paper briefly describes a comprehensive approach to marine risk management developed by MARAD in the face of pressures on port traffic by larger and more cost effective ships. The paper notes that the Coast Guard is on public record indicating that a probabilisitc safety analysis is not a sufficient basis for the specification of maritime safety procedures. To accommodate the human factor, MARAD used its operational ship's simulator at CAORF as its primary analytical tool in face of the mathematical intractability of human performance modeling. The approach involves identification of risk identification and mitigation efforts that can be used in a relative sense to order different situations/consequences as to relative risk and relative cost/benefits. Several analytical risk analysis techniques other than simulation are used as a form of supplemental analysis. The methodology involves identifying a hierarchy of risk categories appropriate to the situation under evaluation. The methodologies involved include: personnel and public risk exposure analysis, simulation (either fast-time simulations and/or real-time man-in-the-loop simulations), casualty analysis, safeguard analysis, salvage analysis, and environmental effects analysis. The paper describes the application of the methodology to the Santa Barbara Channel and then proposes its application to the Texas coastal area and the Lower Mississippi River.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
☑	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 83-S-1

Citation:
Schryver, J. C., *Evaluation of ARPA Display Modes and Traffic Assessment Through CAORF Simulation of Collision Avoidance Situations*, CAORF, National Maritime Research Center, Kings Point, NY, October, 1983. (CAORF 13-8128-02, DTMA 91-82-D-20004).

Abstract:
A study is described which utilized the shiphandling simulator at the Maritime Administration's Computer Aided Operations Research Facility (CAORF). Collision avoidance problem solving was assessed with variable modes of presentation on an Automatic Radar Plotting Aid (ARPA). One group of licensed masters and mates with watchstanding experience was aided with relative motion vectors attached to target echoes in an unstabilized, "heading up," relative motion PPI display. A second group was similarly aided with true motion vectors. During experimental trials, test subjects entered the simulated bridge to observe a developing traffic situation and assume the conn. The situation was assessed by the subject until an irreversible course of action was initiated. Each subject was tested in nine open-sea scenarios differing in traffic ship number (2, 3, or 5), initial rang (3 nm, 5 nm, 7 nm) and traffic speed (10 kt, 15 kt, 20 kt). Subjects using true vector displays were significantly more likely to take evasive action as compared to those using relative vector displays, but the effect was confined to mates.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 83-S-2

Citation:
Smith, M. W., Multer, J, and Schroeder, K. R., *Simulator Evaluation of Turn Lighting Effectiveness for Nighttime Piloting*, 5th CAORF Symposium, 1983, B3-1 - B3-11.

Abstract:
The paper describes the results of the 1983 study by Multer and Smith (CG-D-49-82) that evaluated the effects on nighttime piloting of flash characteristics, number of turn lights, and ship size. The simulation involved a 30,000 dwt and 80,000 dwt ship transiting a 500-foot channel with a 35-degree left turn. Nine pilots were involved in the experiment. The principal findings are:

- Quick flash is more effective for turn lights than are slower flash rates
- Slower flash rates (2.5 and 4 sec.) are not meaningfully different in effectiveness
- Synchrony of turn lights does not increase their effectiveness during the turn
- Three buoys in a turn (rather than two) are more important for a larger ship

Comparison of nighttime performance in this experiment with daytime performance in previous experiments under comparable conditions revealed a different turn strategy. In particular, at night, they made a more abrupt turn closer to the centerline which resulted in poorer performance immediately beyond the turn.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 83-U-1

Citation:
US Coast Guard, Office of Navigation, *Short Range Aids to Navigation Study*, Washington, DC, June 1983.

Abstract:
This study is a comprehensive review of the Short Range Aids to Navigation (SRA) program and of the ships, facilities, and personnel assigned. The study is a response to an OMB request for an analysis consistent with Circular A-76. The study addresses SRA elements in four segments: offshore, coastal and inland, Great Lakes, and river. In each section, the study addresses servicing requirements, tender utilization and cost, system planning factors, long term system alternatives, cost analysis of operational alternatives, and a summary and recommendations. The study concludes that the Coast Guard should continue to operate and man all buoy tenders and ANTs with military crews. The study concluded that the total number of aids deployed is adequate for present safety of navigation requirements, and that there were no developments in the foreseeable future that would permit a reduction of the aids employed or reduce the size and weight of present equipment. The present number and deployment of tenders are generally necessary to meet the existing discrepancy response criteria. The Coast Guard should consider faster tenders when planning for replacement vessels. For the Great Lakes, use of tug/barge combinations could result in a reduction of buoy tenders.

The study includes a substantive cost analysis that constructs costs for various alternatives using personnel costs (using Coast Guard standard costs), direct operating costs (fuel and maintenance), and capital costs (depreciation). For commercial alternatives, profit and overhead are also included. These constructed costs are used to evaluate the alternatives. The result is that Coast Guard owned and operated is the alternative of choice in all operating segments.

[Note: This study is a very significant compilation of SRA program data.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
☑	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 84-M-1

Citation:

Marino, K. L., Smith, M. W., and Moynehan J. D., *Aids to Navigation SRA Supplemental Experiment Principal Findings: Performance of Short Range Aids under Varied Shiphandling Conditions*, Eclectech Associates Division of Ship Analytics, Inc., North Stonington, CT, September 1984. (CG-D-03-84, 83-U-166, NTIS AD-A148366).

Abstract:

This report documents one of the simulator experiments in the Performance of Aids to Navigation Program. The purpose of this experiment was to supplement the visual experimental data that were used to develop the SRA/RA manual and to further extend it. The experiment developed updates the "correction factors" that had been used in the 1982 manual. The experiment introduced a "relative risk" measure as an overall performance measure. The results indicated that there is a marked decrease in risk with increased vessel speed under buoy densities that allow the pilot to give optimal control orders. As channel width increased, performance for the 30,000 DWT ship decreased; the decrease was less for the 80,000 DWT ship, indicating that the risk was less than previously estimated for the larger vessel. Data for turn maneuvers were also collected but no performance correction factors were developed due to the different way that turn arrangements are handled by pilots. The experiments were run under difficult shiphandling conditions. Performance was more precise under easier shiphandling conditions. The difficult decision have built conservatism and safety margin in the manual because of the low frequency of encountering the more difficult conditions. Overall, the use of the new data in the manual has resulted in a decrease of conservatism and more distinction among conditions. (Includes references to predecessor studies.)

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 84-T-1

Citation:

Thacker, J.R., *An Evaluation of Flashtube Signal Characteristics,* Research and Development Center, Groton, CT, August 1984. (CG-D-26-84, CGR&DC 13/84, NTIS AD-A149569).

Abstract:

The Coast Guard has long been interested in using flashtubes as an aid to navigation. They are highly conspicuous and energy efficient. In the single-flick operation mode, mariners report difficulty in fixing the exact location of the flashtube, presumably due to the extremely short "on" time (less than 10 milliseconds). This factorial experiment investigated the effect on observer performance as each of three factors was varied: (1) flash repetition rate, (2) flick frequency, and (3) number of flicks comprising the multiflick flash. Analysis of variance showed that all main factor effects and some interactions were significant. Observer performance can be predicted by specifying the three factors.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 85-H-1

Citation:

Hwang, W., *The Validation of a Navigator Model for Use in Computer Aided Channel Design*, 6th CAORF Symposium, 1985, A5-1 - A5-17.

Abstract:

This paper describes the use of real-time simulator test data to validate the CAORF autopilot. Panama Canal Pilots were used in the real-time simulations to yield an average behavior based on the observed data. These results were used to adjust the autopilot to represent a typical pilot. The results indicate that the representative autopilot is consistent in performance with the real pilot, but human pilots are more flexible because of their adaptability to the environment, the situation, and the ship that they control. The tasks modeled involve trackkeeping and involve passing maneuvering. The autopilot is structured to follow a trackline or sailing line. In a passing situation, the sailing line becomes another trackline for the autopilot to follow. A control loop uses rudder angle and engine RPM to make appropriate course changes to maintain the desired trackline/sailing line. The simulation is placed in the Gaillard Cut in the Panama Canal.

[Note: The paper does not describe how the autopilot obtains position information in order to determine whether corrective actions are required.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
☑	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 85-K-1

Citation:

Kaufman, E. J., *Optimizing the Use of Compressed Time Simulation as a Screening Device for Alternative Channel Layouts*, 6th CAORF Symposium, 1985, C1-1 - C1-8.

Abstract:

This paper describes a decision strategy that is used to reduce the number of experiments run in a project that considers various alternatives for the Panama Canal Widening Project. The experiments use a compressed time simulation using an autopilot for each experimental setting. The design incident involved a meeting situation with two Panamax vessels in close proximity to a turn, a situation considered unsafe with the current canal channel design. The new decision strategy examines operational conditions and layout conditions. Operational conditions include speed of ships when meeting took place, availability of tug assistance, use of engine RPMs to increase rudder effectiveness, the anticipation distance for moving from centerline to passing line, and the cross-track positions of the ship when the encounter began. The layout factors included radius of curvature of the turn, curve width, transition zone, and underkeel clearance. A run involving a given set of operational conditions and layout conditions is executed and evaluated with respect to a safety criterion. If it passes, all less economical layout alternatives are eliminated for the operational conditions being used. If the run fails the criterion, all less effective sets of operational conditions are eliminated for the given layout condition. The results is the identification of a subset of layout alternatives and the level of operational effectiveness necessary for safe passage is identified for each.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
☑	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 85-M-1

Citation:
Marino, K.L., Moynehan, J. D., and Smith, M.W., *Aids to Navigation Principal Findings Report: Implementation as a Test of Draft Design Manual,* Eclectech Associates Division of Ship Analytics, Inc., North Stonington CT, April 1985. (CG-D-04-85, 84-U-252, NTIS AD-A154428).

Abstract:
This report documents part of the research in the Performance of Aids to Navigation Program, the objective of which is to provide guidelines for the evaluation and design of aids to navigation systems in restricted waterways. A major effort has involved the evaluation of various aid systems under a variety of conditions on a marine simulator. This report describes the implementation task which was to experimentally test the draft manual's guidelines for evaluation and design of aids to navigation systems in restricted waterways. The Upper Narragansett Bay near Providence, Rhode Island, was the channel in which the draft manual's recommendations were implemented. Data was primarily collected at sea in both the original and modified channel. The at-sea data collection electronically tracked 30,000 DWT tankers inbound in the Upper Narragansett Bay. Data was also collected on the marine simulator developed for the project. The results of the at-sea implementation verified the recommendations of the draft manual, indicating that the manual and the basic assumptions built into it are sound. Based on the implementation experience, the final design manual should be more flexible, enabling the user to adapt the guidelines to unique conditions, and should be less conservative and more accepting of a variety of channel markings.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 85-M-2

Citation:

Moynehan, J. D., and Smith, M.W., *Aids to Navigation Systems and Meeting Traffic,* Eclectech Associates Division of Ship Analytics, Inc., North Stonington, CT, June 1985. (CG-D-19-85, 85-U-326 & 26-8403-02, NTIS AD-A157905).

Abstract:

This report documents part of the research in the Performance of Aids to Navigation Program, the objective of which is to provide guidelines for the evaluation and design of aids to navigation systems in restricted waterways. A major effort has involved the evaluation of various aid systems under a variety of conditions on a marine simulator. This experiment was designed to evaluate aid arrangements, identified as versatile and high-performing in a variety of situation, in their support of meeting traffic. The data provided a realistic-to-conservative estimate of the risk of collision when large ships meet in narrow channels. The simulation included a realistic view of the traffic ship, bank and ship interaction efforts and an unpredictability to the track on which the traffic ship approached. The basic result is that a conservative marking for a turn and recovery region is essential. Under that arrangement a less conservative spacing of gates in a straightway (1.25 NM) is feasible with only a minor increase in risk. Even in difficult shiphandling situations, increasing aid density beyond that specified in the design manual will not help.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 85-O-1

Citation:

O'Hara, J. M., and Brown, W. S., *An Investigation of the Relative Safety of Alternative Navigational System Designs for the New Sunshine Skyway Bridge: A CAORF Simulation*, Computer Aided Operations Research Facility (CAORF), September 1985. (CAORF 26-8232-04).

Abstract:

This report describes an investigation performed for the Florida State Department of Transportation to determine the relative safety afforded the new Sunshine Skyway Bridge by three alternative navigational system designs. A navigational system design was a specific configuration of channels, aids to navigation, and shipboard navigation aids in the vicinity of the bridge. Nine scenarios were developed to compare bridge safety of four designs during the transit of a 160,000 dwt tanker. Seven Tampa Bay pilots made the transits, generally in adverse conditions consisting of heavy fog or thunderstorms.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
☑	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 85-S-1

Citation:
Schroeder, K. R., Smith, M. W., and Moynehan, J. D., Aids to Navigation System and Meeting Traffic, *Proceedings of the 6th CAORF Symposium*, May 1985, B8-1 - B8-9.

Abstract:
This paper includes a brief overview of the fourteen simulator experiments conducted over a period of six years to evaluate aid to navigation systems. The principal purpose of the paper is to report the results of the latest experiment that evaluated visual aid to navigation systems in the presence of meeting traffic. The simulation involved both 30,000 dwt and 80,000 dwt tankers as both ownship and as traffic ship. For each experimental run, traffic ship behavior varied to eliminate learning effects by the subjects (licensed pilots). The experiment used aid arrangement identified in early experiments as high performing and supporting basic maneuvers in narrow channels. Early experiments did not include bank effects to eliminate a source of information and force reliance on aid systems. In the present experiment, bank effects were included. A comparison run without bank effects showed that the inclusion of bank effects kept the vessel farther from the channel edge and closer to the traffic ship. Overall, the results under the more demanding meeting situation did show that these arrangements were also appropriate for meeting traffic. The big effects on performance were caused by shiphandling variables. Ship size and ownship distance beyond the turn at meeting had the largest effect on risk.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 86-G-1

Citation:
Greenberg, L., Bresnick, T.A., Ulvila, J.W., Marvin, F.F., Clark, G.P., and Stanley, J.G., *SRA Resource Management Final Report on Task 1: Measures of Effectiveness*, Mandex, Inc., Springfield, VA, September, 1986. (CG-D-20-86, NTIS AD-A 173705)

Abstract:
This report documents study results for the first phase of a research effort designed to develop a decision model (or set of models) capable of supporting the resource management activities of the Coast Guard's short range aids to navigation program. The purpose of this part of the study was to develop measures of effectiveness for program activities that would then be used in the development of Resource Management Tool (RMT). The report includes a brief review of related aton analyses and their value in developing the RMT. The study includes the results of meetings with various user groups. That process led to the development of a long list of potential measures of effectiveness. The study refined and condensed the list that resulted in a benefits hierarchy and a cost hierarchy, both of which contained several levels of attributes. The benefits hierarchy included safety (avoidance of accidents), timeliness (avoidance of delays) and other benefits (e.g., mariner interests, CG interest, other government interests, and public interests). The cost hierarchy considered both CG costs and other federal government costs. A weighting approach was then used to develop weights for the lowest level attributes. Various resource allocation alternatives could then be compared on the several attributes and a resulting weight or value computed for each alternative that indicates the ranking of the alternatives. The report includes several appendices on Multiattribute Utility Theory and several decision analysis approaches.

[Implementation note: The weighting aggregation overlooks the bias introduced by the uneven structure of the hierarchies. Ratio comparisons are not made directly.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
☑	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 86-W-1

Citation:

Winslow, T.S., and Mandler, M. B., *An Evaluation of the Hypothesis that Laser Light is More Conspicuous than Incandescent Light,* Research and Development Center, Groton, CT, May 1986. (CG-D-16-86, CGR&DC 8/86, NTIS AD-A170823).

Abstract:

It has been thought that laser aids to navigation might appear more conspicuous than aids employing conventional light sources. Two experiments rigorously tested the hypothesis that laser light is more conspicuous than incandescent light. Based on the experimental data, it was concluded that at "practical" design illuminance levels, no significant conspicuity advantage would be gained by replacing existing navigational aids with laser aids to navigation. Calculations show that a significant conspicuity advantage is likely to be obtained if the mariner uses a narrow bandpass filter (3-10 NM) centered at the laser wavelength. The illuminance from the laser will be relatively unaffected, while the illuminances from all background lights will be dramatically diminished. An additional section compares the electrical efficiency of a standard Coast Guard FA-240 range light with a laser aid configured for the same application. For equal input power, the FA-240 is shown to produce 10 times the luminous intensity of the laser aid.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 87-C-1

Citation:
Cline, A. K., and King, D. H., *Route Planning Model Design Report*, Pleasant Valley Software, Austin, TX, December 1987.

Abstract:
This report presents a design for a route planning model to be incorporated into Ship Aids to Navigation simulation program. It includes discussions of the route selection evaluation criteria and the algorithms to be employed for determining routes. Specifications for ship, buoy, geography, and weather parameters are given as well as a suggested interface between the route planner and the simulator. Also included is a discussion of evaluation criterion for the simulator.

[Note: This algorithm was incorporated in the ANGEL simulation. The paper contains a detailed formulation of the route planning model using a greedy heuristic and simulated annealing. Considerable detail is provided on the interface to ANGEL. The authors' consistently used *bouy* throughout the report.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 87-U-1

Citation:
US Coast Guard, Short Range Aids to Navigation Division, *Evaluation of Impact in Advances in Buoy Technology on Replacement of WLB/WLM Capability*, Washington, DC, January 1987a.

Abstract:
This paper addresses the impact of technology changes on the requirements for WLB/WLM acquisition. Specifically, the paper focuses on plastic versus steel, buoys to beacons, and GPS satellite navigation. The paper includes a good review of the plastic buoy research to date and concludes that steel buoys will still be required in the exposed and semi-exposed environments. The buoys to beacons implementation of the Booz Allen study were not implemented as extensively as recommended. The paper suggests that a major reason was the limited availability of the construction tenders. The paper notes that changes in the servicing interval recommended by Booz Allen were implemented in 1974 and resulted in reducing the WLB/WLM fleet from 38/17 to 28/12 in 1987. This review did not mention the role of ANTs in this implementation. The paper concludes, citing several international authorities, that the use of satellite technology (then expecting 100 meter accuracy) will not affect the need for short range aids to navigation. Even if GPS could supplant the need for the 9 foot buoys, this would only reduce the lift capability for WLBs. Seakeeping ability would remain the same. The paper noted the ongoing conversion to solar power for buoys, but concluded that the same lift capability would be required for WLB/WLMs.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology	☑	Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 87-U-2

Citation:

US Coast Guard, Systems Technology Division, *Evaluation of Impact of Advances in Buoy Technology on Replacement of WLB/WLM Capability*, Washington, DC, March 1987b.

Abstract:

This memo is the concurrent clearance by the Chief, Systems Technology Division on the January, 1987 report by the Chief, Aids to Navigation Division of the same title. The memo reviews the technological improvements, noting that potential changes to the configuration and deployment of some SRA systems may affect the characteristics of the required WLB/WLM capabilities. The memo note the effect of using lightweight materials and synthetic moorings for buoys. It notes the increased reliability of buoys power systems that followed the move to solar power. It indicates that research to reduce signal power could extend the power system life and reduce the servicing frequency requirement. It reports on the Automated Aid Positioning System that may significantly increase the productivity of the tenders. The memo suggests that the articulated light may serve as a suitable replacement for many of the larger aids, reducing the lift capability if these are implemented. The memo suggests that GPS will reduce the need for some of the off shore floating aids. The memo concludes that the capabilities of the existing fleet will be required in the future, but cautions that some changes that may affect the numbers may be appropriate.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology	☑	Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 87-U-3

Citation:

US Coast Guard, Short Range Aids to Navigation Division, Office of Navigation, Chief, *WLB Multi-Mission Utilization and Replacement of WLB Capability*, Washington, DC, June 1987c.

Abstract:

This paper addresses questions posed by OST regarding multi-mission use of WLBs. The report documents WLB usage for FY82-FY86 (includes all Abstract of Operations hours) by district. The report shows that the average SRA use was relatively constant over the past five years, averaging about 58% of all underway time. The report notes the excess time available is used in other missions. However, the paper emphasizes that the replacement WLBs will be planned to only meet SRA requirements--no multi-mission use will be used to justify the number and location of WLBs. It is recognized that some excess capability may be available in certain areas depending on the SRA load.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 87-U-4

Citation:
US Coast Guard, Short Range Aids to Navigation Division, Signal Management Branch, *An Evaluation of Servicing and Discrepancy Policies for Short Range Aids to Navigation*, Washington, DC, June 1987d.

Abstract:
This paper addresses questions posed by OST regarding routine servicing of aids to navigation and aton discrepancy response policy. The paper reviews the changes in both the servicing policy and discrepancy response policy over the previous 20 years. The only major servicing policy change occurred following the Booz Allen study. The 14 May 1973 amendment to the ATON Manual significantly extended all servicing intervals except for recharge intervals. The US policies are compared with other nations and it is noted that the US policies are more relaxed than any other country. The lamps and guano on solar panels and daymarks are reported as limiting factors on increasing servicing intervals. Environmental factors also affect when aids can be serviced. Extending an annual service to 18 months may schedule it when weather is unfavorable. The existing annual schedule means that senior personnel on ships will visit an aid twice during a normal tour--the first visit is with more experienced personnel and the second visit as the senior person. Extending the service interval may mean that there will be no person experienced with a particular aid when it is serviced. The report concludes that the present servicing policy can not be extended beyond a year without increasing discrepancy rates or seriously degrading daymark signal quality. The paper also reviewed discrepancy response policy. Before 1972, all discrepancies were to be responded to within two hours of notifications. The policy was relaxed in 1972 where time thresholds were established for the time to correct discrepancies (now in four categories: immediate, priority, routine, deferred). That policy was changed to a guideline in 1979. Following a 1979 GAO audit that addressed discrepancy response, the CG revised the policy in 1982 to provide timelines for responding to (not correcting) discrepancies. This was implemented using a "Discrepancy Response Decision Guide. The paper emphasizes that under this policy, buoy tender numbers and homeports are not seriously affected by discrepancy response policies. It is the workload that is the key factor, of which discrepancy response is only a minor part. The paper reports the use of the Surface Force Mix (SFM) program to analyze the effect of alternative servicing policies and discrepancy response policies. The conclusion is that the resource need is fairly insensitive to relaxing these policies and indicate that the magnitude of change is on the order of two to three ships.

[Note: This paper appears to be more emotional than other reports. The "analysis" results using the SFM are not included. It seems that a two-to three ship reduction is **not** insignificant.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
☑	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 87-W-1

Citation:

Walker, R.T., Pritchett, C.W., Lincoln, W.B., and Stevens, M.J., *U.S. Coast Guard Buoy Tenders: Historical and Projected Usage*, USCG Research and Development Center, Groton, CT, June, 1987. (CG-D-18-87, NTIS AD-A183653).

Abstract:

This report identifies the capabilities provided by the current fleet of 28 offshore buoy tenders and 12 coastal buoy tenders by summarizing the employment history over the past five years. Projections for future buoy tender usage are also presented. The coastal buoy tenders have spent nearly 87% of their time servicing aids to navigation over the past five years. The balance of their time was spent supporting other missions such as search and rescue, law enforcement, training and other miscellaneous missions. Offshore buoy tenders have been used s multi-mission platforms, spending about 56% of their time servicing aids to navigation, 13% on search and rescue, 9% on law enforcement and 7% on training. The offshore tenders are also engaged to a lesser degree in military operations, icebreaking, and a variety of miscellaneous missions.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 87-Y-1

Citation:

Young, R., Allen, S., Bitting, K., Kohler, C., Walker, R., Wyland, R., and Pietraszewski, D., *Survey of Technology with Possible Applications to United States Coast Guard Buoy Tenders: Volume I--Technology Assessment*, USCG Research and Development Center, Groton, CT, September, 1987. (CG-D-06-88, R&DC 04/87, NTIS AD-A193918)

Abstract:

This report contains state of the art summaries and projected trends for major technology areas pertinent to buoy tender design. A separate volume (II) contains an annotated bibliography of the citations obtained during the technology survey. Volume III contains a description of a relational model and documentation of a computerized database used for storage and analysis of buoy tender data. Volume I addresses the state of the art in the following areas: foreign aids to navigation vessels; foreign aids to navigation practices; offshore supply support/work vessels; hull forms for seakeeping; propulsion systems; weight handling systems; and vessel automation, navigation, control and monitoring. The survey focused on technologies suitable for existing buoy designs and mooring hardware. The study found very little documentation of foreign aton practices. A survey was used to get a basic picture of the scope of operation. Eight countries responded to the survey.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings	☑	Buoy/Beacon Design, Hardware and Moorings
☑	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 88-B-1

Citation:

Brown, W. S., Smith, M. W., and Forstmeier, K. G., *Targets of Opportunity Experiment: Short Range Aids / Radio Aids Principal Findings: Waterway Performance Design and Evaluation Study*, Ship Analytics, Inc., North Stonington, CT, June 1988. (CG-D-3-87, 86-U-439, R&DC 15/88).

Abstract:

This report describes one of a series of man-in-the-loop simulation studies designed to assist the USCG in the design and evaluation of systems of aids to navigation in restricted waterways. Previous experiments have examined various configurations of buoys in the absence of any other visible objects. The present study was undertaken to determine the extent to which representative visual surroundings would augment the effectiveness of a system of aids. The results indicated that aids to navigation are in fact more effective in typical visual surroundings than they are with no other objects in the scene. It was found that the amount of benefit associated with the visual scene was influenced by a variety of factors including the density of objects in the scene and the distance of objects from the waterway. However, the presence of a visual environment was generally not found to improve performance for a suboptimal buoy configuration to that of an optimal configuration. The implications for waterway design are discussed and guidelines for the evaluation of visual environments are presented.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 88-B-2

Citation:

Brown, W. S., Smith, M. W., and Conway, J. A., *Positioning Experiment: Short Range Aids / Radio Aids Principal Findings: Waterway Performance Design and Evaluation Study,* Ship Analytics, Inc., North Stonington, CT, October 1988. (CG-D-09-89, 87-U-512, CGR&DC 4/88 NTIS AD-A210421).

Abstract:

This report describes one of a series of man-in-the-loop simulation studies designed to assist the USCG in the design and evaluation of systems of aids to navigation in restricted waterways. Previous experiments have examined various arrangements of aids while treating the aids themselves as fixed, rather than floating objects. The present experiment evaluated the effects on performance of buoy excursions from their assigned positions. The *distance* of buoy excursion had non-significant, but systematic effects on waterway performance and risk. The *direction* of current and buoy excursion had major effects on shiphandling, waterway performance, and risk. The report contains interim guidelines to allow application of the findings to the procedures in the SRA Systems Design Manual. Although the report concludes that floating aids do decrease performance, or increase risk, compared to fixed aids, this difference has little consequence with respect to the general-purpose design and evaluation procedures of the Systems Design Manual.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 88-C-1

Citation:
Cline, A. K., and King, D. H., *Aids to Navigation Simulation Model: Route Planning Model*, Pleasant Valley Software, Austin, TX, June 1988.

Abstract:
This report documents the Route Planning Model. It includes a Users Guide that describes the inputs and outputs from RPM and the interface with ANGEL, an Aids to Navigation General Even-step Logistics (ANGEL) model used to simulate buoy tender operations. ANGEL is written in SIMSCRIPT II.5. The RPM computes the routing of a given ship in its servicing of its assigned buoys. The system documentation describes how RPM constructs a schedule for a buoy tender and the internal operation of the system. An appendix shows the schedule of buoy tender activities generated by RPM for the test case of Long Island Sound.

[Note: This project was never officially completed, but the code is available at the R&DC. Follow-up discussions at the R&D Center suggests that this model should be implemented on a current simulation language with full animation capabilities if it is to be used in the future.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 88-K-1

Citation:

Kingsley, L. C., Klesczewski, K. S., and Smith J. A., A Logistics Model of Coast Guard Buoy Tending Operations, *Proceedings of the Winter Simulation Conference*, Washington, DC, 1988.

Abstract:

This paper describes a discrete event simulation model written in SIMSCRIPT II.5 for evaluating given buoy tender designs operating in selected geographical regions. Since each tender may have characteristics which limit its ability to travel in some waters, the model must plan the tender's travel itinerary. In addition, the model uses a set of tools that automatically generate meta-models for verification.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 88-P-1

Citation:

Pietraszewski, D., Spalding, J., Viehweg, C, and Luft, L., U.S. Coast Guard Differential GPS Navigation Field Test Findings, *Navigation: Journal of the Institute of Navigation*, Vol. 31, No. 1, 55-72, 1988.

Abstract:

This paper reports on the Coast Guard research program to investigate C/A-code GPS and methods to improve its accuracy and integrity. The paper reports on the results of an evaluation of a differential GPS system. The proposed system was tested on both static and dynamic modes. Analysis of the stated DGPS test results demonstrate that the performance was within the 8m to 20m target established at the start of the project. During the best conditions, the results were better than 8m (2 drms). The dynamic position involved a 42' Coast Guard patrol boat operating at 10 knots and 20 knots. A microwave ranging system was used to monitor the boat position. Again, the performance was within the 8m to 20m target. The various maneuvers demonstrated that carrier-aided DGPS is accurate enough to expose errors in the instrumentation or truth measurement. The reports notes several difficulties: no standard algorithm exists for "earth rotation correction." The issue of parametric synchronization should be reviewed by the RTCM SC-104. Because carrier-aiding is important in this application, the proposed RTCM SC-104 messages need to be reviewed to ensure that the necessary solutions for correcting carrier-aids navigation have been included. The report identifies the important tests conditions that may affect the results if changed,

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
☑	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 88-U-1

Citation:
US Coast Guard, Office of Navigation Safety and Waterway Services, Chief, *WLB/WLM Replacement Sponsor's Requirements Documents*, Washington, DC, November 1988.

Abstract:
Enclosure (1) to this memo 16500 dated November 21, 1988 includes the detailed Sponsor's Requirements Document for the WLB replacement vessel. The SRD specified the operational mission of the vessel, and expected level of operations. Projected employment days are specified by category (includes 150 underway ATON days each year). The SRD details all operational capabilities required and specifies required systems.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
☑	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 89-G-1

Citation:
Gynther, J. W. and Smith, M. W., *Radio Aids to Navigation Requirements: the 1988 Simulator Experiment*, U.S. Coast Guard Research and Development Center, Groton, CT, November, 1989. (CG-D-08-90, NTIS AD-A226235)

Abstract:
This study evaluated the use of electronic navigation systems for piloting deep-draft vessels in restricted waterways. The experiment was conducted using the ships bridge simulator at the USCG Academy. The purpose of the experiment was to evaluate accuracy requirements for electronic navigation systems for use in periods of low visibility, and to examine the trade-offs among accuracy, visibility, and the sophistication of the device. Three display devices were used simulating existing or soon to be available devices. One device (A) displayed the waterway in a track-up display. Speed, both along track and crosstrack, was provided digitally. Another device (B) was similar with a north-up display, and a third display (C) only provided digital information. The scenario involved navigating a 500-foot wide channel with a 35° left turn. All of the electronic devices resulted in better performance than visual piloting in the recovery and trackkeeping sections. Devices A and B resulted in better turn performance than visual piloting in low visibility. The digital only device (C) was inadequate for turns in low visibility. Pilot performance in the 8-20 meter 2drms range of accuracy approximated visual piloting performance. The findings suggest that navigation in restricted waterways is possible in reduced visibility with the present technology of electronic navigational aids.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 89-T-1

Citation:

Thacker, J.R., *Final Report on United States Coast Guard Aids to Navigation Servicing Trial Contracts*, Draft Report, USCG Headquarters, Washington, DC, October, 1989.

Abstract:

This report includes an overall assessment of CG efforts in contracting ATON servicing on selected waterways. The assessment focuses on contractor performance, CG contract administration, and highlights of issues of concern. Five low risk waterways were considered. All bids received exceeded the government estimate. Of the five areas, three contracts were awarded for operations over two and one-half years (FY87-FY89). Performance ranged from unsatisfactory to excellent as follows: Merrimack River and Ipswich Bay--unsatisfactory; New Jersey ICW--unsatisfactory; Snake and Willamette Rivers--excellent. Discrepancy response, quality of work, and timely, accurate reports are the primary areas where contractors seem to have the most difficulty meeting contract requirements. Coast Guard contracting officers were located at MLCs, but COTR and QAE personnel were in district offices and local units. There appeared to be timeliness issues in administering the contracts and the report concludes that the CG ability to administer these contracts is marginal. Routine contract administration was marked by long delays. The report concludes that there was no cost, technical, or administrative advantage in contracting out this ATON function to commercial activities.

[Note: Because this study was conducted internally, a final report was not prepared. Rather, a contracted study was conducted by the Volpe National Transportation Systems Center (see 90-T-1) to evaluate the contracting trial.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
☑	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-D-1

Citation:

Daidola, J. C., Basar, N. S., Johnson, F. M., and Walker, R. T., *Buoy Technology Survey USCG Buoy Development Review*, M. Rosenblatt & Son Inc., New York, NY, October 1990. (CG-D-04-92, R & D C 10/90, NTIS AD-A247183).

Abstract:

This report reviews the research and development efforts on buoys by the CG since 1962. The results are based on an extensive literature survey and interviews with ATON personnel at CG Headquarters, the Research and Development Center, district (oan) offices, buoy tender crews, industrial facilities, and a limited number of buoy manufacturers. The review is limited to the buoy itself and does not include the moorings, signal, etc. The buoy development projects identified include the following:

1. Articulated beacon development, 1980-present
2. Collision tolerant pile structure project, 1985-1987
3. Foam buoy development project, 1982-1988
4. 2 CPLR lighted foam buoy project, 1986-1987
5. 4x11 lighted foam buoy project, 1985-1987
6. Fast water buoy development project, 1972-1978
7. 5th and 6th class plastic buoy project, 1972-1978
8. Second class buoy project, 1972-1973
9. Lightweight lighted discrepancy buoy project, 1971-1976
10. 5x9 LPR buoy development, 1970-1972
11. CANUN buoy project, 1968-1970
12. Evaluation of plastic vs. steel for buy hulls, 1968-1970 (Booz Allen)
13. Numerical model of shallow water buoys, 1978-1981
14. Buoy motion prediction project, 1975-1976
15. Buoy hull and mooring model application study, 1970-1974
16. 8x26 BE (RR) buoy, 196 design tests, 1962
17. Exposed location buoy project, 1980-present
18. Unlighted ice buoy project, 1981-1984
19. 6x16 LI and 7x20 LI ice buoy project, 1979-1984
20. Great Lakes ice buoy demonstration project, 1973-1975
21. Wave activated turbine generator project, 1973-1977
22. Explosive embedment anchor project, 1970-1976
23. Detection of lights on rolling buoys, 1987
24. Evaluation of structures versus buoys, 1968-1970 (Booz Allen)
25. SRA servicing system study, 1968-1970 (Booz Allen)
26. Anti-fouling rubber coating for buoys, 1966-1979
27. Accordion buoy project, 1962-1964

The literature review identified several areas for further research and development efforts:

- River buoys
- Large lightweight buoys
- articulated beacons
- correlation of vessel size to buoy characteristics
- LNB replacement
- Measure of buoy effectiveness
- Unlighted sound buoys

The interviews suggested improvements in the following areas:

- Buoy hull design
- Construction materials
- Payload and equipment
- Improvements to existing buoys
- Standardization

In the solicitation for the study, the CG had identified the following areas which are discussed in the report:

- Insufficient cataloging of buoy design information
- Buoy relief and maintenance cycles
- Buoy watch circles
- Buoy shape significance
- Optimal payload support
- River buoy survivability

The report includes 203 references that have been included in a CG computer database for both Buoy Technology Bibliography and Buoy Technology Abstracts.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-K-1

Citation:
Kingsley, L. C., Klesczewski, K. S., and Smith J. A., *Comparing US Coast Guard Buoy Tender Performance Using Simulation*, Research and Development Center, Groton, CT, June 1990. (Draft report)

Abstract:
This report describes the ATON General Event-Step Logistics model (ANGEL). This model is a discrete event simulation model written in SIMSCRIPT II.5 for evaluating given buoy tender designs operating in selected geographical regions. The model includes the following tender activities: working of a buoy, docking to resupply the tender, R&R for the crew, anchoring due to bad weather, waiting for the desired time in which to work a buoy, and the transiting of the tender between a set of buoys. ANGEL incorporates a Route Planning Model (RPM) to schedule the buoys that the tender is to service. Environmental factors are incorporated using probability distributions of various types. The model results are shown for two examples: Long Island Sound, and the 13th District. The model results demonstrate the relative performance of alternative buoy tender designs using the sponsor's performance requirements as evaluation criteria.

[Note: This report was never published as an approved technical report. The model relies on visual positioning of aids.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-K-2

Citation:

Krammes, S., and Crowell, R., *Demonstration of the Differential Global Positions System (DGPS) for Buoy Positioning*, United States Coast Guard Research and Development Center, October 1990.

Abstract:

This report describes the evaluation of DGPS (implemented in the Laptop Automated Aid Positioning System, LAAPS) as a primary means for positioning aids in place of horizontal sextant angles. The evaluation involved positioning 29 buoys in Narragansett Bay. Test results indicated that the mean difference between the DGPS position and the horizontal sextant angle position was 2.3 meters. The maximum distance between the two systems was 5.1 meters. The results strongly support using DGPS as a replacement for horizontal sextant angles. The report includes all of the data and analyses used in the test as well as a copy of a draft users manual for LAAPS. Notable is the reported "smoothness" of the display using DGPS due to the inherent system and accuracy with DGPS. In LAAPS, the receiver position solution is updated every second and involves minimal averaging.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-L-1

Citation:

Laxar, K., Luria, S. M. and Mandler, M. B., *A Comparison of Parallax and Single-Station Range Aids to Navigation: Final Report*, Naval Submarine Medical Research Laboratory, December, 1990.

Abstract:

This report describes the findings with respect to navigational sensitivity afforded by current and proposed range display systems, and permit the evaluation of implications of replacing parallax ranges with the single-station ranges. The ability of observers to detect deviation from range axis and motion across range axis was determined for seven types of range display systems. When compared with parallax range system, the single-station ranges could provide comparable navigational sensitivity under certain conditions, but were characterized by greater uncertainty on the part of the observers.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-M-1

Citation:

Mandler, M. B., and Smith M. W., Precision Electronic Navigation in Restricted Waterways, *Proceedings of the 46th Conference of the Institute of Navigation*, Atlantic City, NJ, June 1990.

Abstract:

This paper reports the results of an experiment designed to determine the accuracy required of electronic navigation systems for navigation (of deep-draft vessels in restricted waterways) in low visibility, and the tradeoffs among accuracy, sophistication of the electronic display device, and visibility. The experiment was conducted on a ship's bridge simulator at the USCG Academy. In the experiment, pilots were generally successful in transiting the channel when there were known errors in electronic position information, even in severely reduced visibility. However, a majority of the pilots had difficulty with a severe turn in zero visibility. The findings suggest that navigation in restricted waterways is possible in reduced visibility with the present technology of electronic navigational aids.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
☑	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-R-1

Citation:
Rosenblatt & Son, Inc., *Users Manual for the Buoy Technology Information System (BTIS)*, August 1990.

Abstract:
This report describes the organization and functionality of the Buoy Technology Information System (BTIS). The purpose of the system is to serve as a design reference tool for aid to navigation buoy design and development. The database is constructed in SQL format and designed to handle up to 1000 buoy records (each containing 56 fields). The data fields contain general information, physical characteristics, related equipment, operating characteristics, and additional data for the buoy platform. The latter data include replacement cost, preparation cost, and monthly servicing cost (1989 dollars).

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings	☑	Buoy/Beacon Design, Hardware and Moorings
☑	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-S-1

Citation:

Smith, M.W., Mazurkiewicz, J., and Brown, W.K., *The Effect of Ship Inherent Controllability on Piloted Performance: The Simulator Experiment*, Ship Analytics, Inc., North Stonington, CT, October, 1990. (CG-D-10-90, R&DC 16/90, NTIS AD-A228968).

Abstract:

This research is part of the USCG Waterway Performance, Design and Evaluation Study to develop a procedure to predict performance or risk in a waterway from the characteristics of user traffic. A sample of seven ships ranging from a 33,000 DWT bulker to a 250,000 DWT tanker making multiple transits under similar channel and environmental conditions were controlled by commercial pilots using the SCANTS simulator at the Coast Guard Academy. A preliminary analysis found that piloted performance data grouped over all transits for a given ship varied as expected with ship size, but was not sensitive to controllability indices. A more detailed analysis found that performance was sensitive to these indices.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-T-1

Citation:

Tung, F.F.C., Skaliotis, G.J., Goeddel, D., Flahive, D., and Cook, R., *Evaluation of Contracting the Servicing of Short Range Aids to Navigation*, Transportation Systems Center, Cambridge, MA, August, 1990.

Abstract:

This report includes an evaluation of the three year trial program of commercial on-site servicing of aids to navigation. Five low risk waterways were considered. All bids received exceeded the government estimate. Of the five areas, three contracts were awarded for operations over two and one-half years (FY87-FY89). This evaluation indicates that performance was satisfactory under all contracts. The selection of the areas to be evaluated was valid and the aids representative of workload in the various districts. The statements of work were not clearly written which may have contributed to higher bids on a fixed price contract when the deliverable was uncertain. The contracts in the 1st and 13th districts were a combination fixed and variable price version. The TSC evaluation of contract costs generally agreed with the Coast Guard's estimate. The TSC evaluation notes that the Coast Guard evaluation of the contractors' performance was unsatisfactory in two cases, but TSC notes that the contractor performance was comparable to that of other Coast Guard units in the program. The TSC evaluation concluded that there does not appear to be any cost or performance advantage for an expanded contracting effort for ANT. The report also indicates that there are no obvious candidates of floating resources that could be eliminated through privatization. Finally, the report concludes that a decision to contract aids should not be based solely on cost. It must consider the impacts on the USCG organization and its ability to respond to myriad statutory and regulatory requirements.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
☑	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 90-W-1

Citation:

Wroblewski, M. R., and Mandler, M. B., *Detecting Buoy Lights: Effects of Motion and Lantern Divergence*, Research and Development Center, Groton, CT, March , 1990 (CG-D-07-90, R&DC 05/90, NTIS AD-A225937).

Abstract:

This report describes a study of buoy motion to quantify the effect that it has on the detection range of a buoy's light signal. Buoy motion data were taken from video recordings of standard USCG buoys in a variety of sea conditions. It became evident during the study that buoy motion is a combination of both list and roll. Properties of a buoy signal light were mathematically combined with the buoy motion data to calculate detection ranges under various conditions, corresponding to the range at which a mariner has an 80% probability of detecting the buoy signal. Results show that buoy motion is a problem. The present buoy lanterns provide an 80% probability of detection range which is only about half of the commonly accepted and published nominal range. This is true for most combinations of weather, buoy size, and flash characteristic. The effect of list alone contributes substantially to buoy signal degradation. Further calculations showed that increasing the vertical divergence of a lens from the currently used 4.2° to between 8.3° and 10.0° (full-width, half maximum) will increase the detection range by approximately 40%.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 91-D-1

Citation:
Daidola, J. C., Basar, N. S., Reyling, C.J., and Walker, R. T., *Buoy Technology Survey Recommendations for Development of Buoy Technologies*, M. Rosenblatt & Son Inc., New York, NY, June, 1991. (CG-D-06-92, R & D C 17/91).

Abstract:
This report incorporates the results from Task A (USCG Buoy Development Review) and Task B (Worldwide Survey of Buoys and Buoy Technology) and develops recommendations for improved ATON buoys. The review of the prior material led to the identification of 57 technologies, later reduced to 54 due to overlaps. Of those, two were already under study by the CG and 21 were not buoy hull related. The study used an evaluation instrument with 31 criteria weighted using a forced choice scale totaling 100 points. Each technology was evaluated against each criterion on a (-5) to (+5) scale. The weighted scores were used to determine which technologies should continued to be considered. A total of 19 (with point scores above the average) made the cut for further evaluation. The final evaluation was made using 30 year net total discounted costs (10% discount rate). Estimates of investment costs, annual servicing costs, 6 year rehabilitation costs, annual losses, and terminal values were made for the existing buoy population (1989 dollars). The key data for the economic analysis is in Table IV that shows the estimated costs for the technology as some percentage of the base. The study indicates that some of the estimates come from the detailed description of the technology (Appendix B) but in other case, estimates were made. The study does not indicate who made those estimates.

The results of the economic analysis provide a rank order for the technologies based on economic savings over the 30 year planning horizon. The highest priority item is the use of FRP and GRP materials (Technology 2.3) with estimated savings in excess of $63 million. This is followed by Systems Approach to Design (Technology 13.1) with estimated savings of $54 million. The study cautions that the results are dependent on the assumptions in Table IV.

[Note: The study did not include any sensitivity analysis with respect to the assumed cost reductions in Table IV. The results implicitly assume that the existing system will be replaced in total by the new system. Implementation, particularly over time, is not considered and time delays are not included in the cost analysis.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
☑	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 91-D-2

Citation:
Darby-Dowman, K., and Mitra, G., *Buoy Tendering - Inspection Timestamps A Prototype Model*, Brunel University, United Kingdom, September 1991.

Abstract:
This report tersely describes an analytical methodology to assign timestamps to buoys for purposes of scheduling. The timestamp identifies the sequence in which the buoys will be serviced. The algorithm considers a set of buoys and a set of ports. It first assigns buoys to the nearest port. For each port, buoys are sorted by radial angle. Buoys are then assigned to maximal tours that are feasible with respect to tour duration (constructed using a nearest neighbor heuristic). The tours were then distributed over a year with inter-tour gaps proportional to the length of the previous tour. The algorithm was tested using the ANGEL simulation. The results indicated significantly better results than currently used in ANGEL and better that manual timestamping that had been previously delivered.

[Note: The use of timestamps for scheduling buoy servicing using this algorithm results in better schedules.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 91-M-1

Citation:
Mazurkiewicz, J. and Smith, M.W., *The Effect of Ship Inherent Controllability on Piloted Performance: Evaluation and Prediction*, Interim Report, USCG Research and Development Center, Groton, CT, September, 1991. (CG-D-10-93, R&DC 21/90)

Abstract:
This report develops statistical relationships between the mean and standard deviation of the extreme points of a vessel hull and several controllability and vessel characteristic variables. The relationships are based on the results of a simulator experiment reported in Smith, M.W., Mazurkiewicz, J., and Brown, W.K., *The Effect of Ship Inherent Controllability on Piloted Performance: The Simulator Experiment*, Ship Analytics, Inc., North Stonington, CT, October, 1990. (CG-D-10-90, R&DC 16/90, NTIS AD-A228968). The report contains a thorough review of vessel controllability factors and is a valuable reference in that regard. Separate sets of equations are developed for the turn region, the turn-recovery region, the recovery region, the entry region, the turn-entry region, channel leg 1 in the trackkeeping region, and channel leg 2 in the trackkeeping region. These equations will be incorporated in a revision to the Waterways Design Manual and will be the primary entry in the computation of the Relative Risk Factor (RRF).

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 91-S-1

Citation:

Spalding, J., Krammes, S., and Pietraszewski, D., *Status of Prototype USCG DGPS Broadcasts from the Montauk Point, New York Radiobeacon*, US Coast Guard Research and Development Center, Groton, CT, March, 1991.

Abstract:

This report describes the development and initial testing of a prototype differential GPS system using the Montauk Point, NY radiobeacon. The report includes a description of the general structure of the prototype DGPS service, contents of the broadcasts, general performance observed over the first six months of operation, and a detailed analysis of a one month period. The evaluation reported that the system met the accuracy goal of 10 meters 95% of the time, when the HDOP is less than 2.3. The prototype demonstrated that marine radiobeacons are a viable method of providing a public broadcast service and provide a signal comparable to various microwave systems used by the Coast Guard. The report strongly recommends DGPS as the preferred method for providing highly accurate positioning information.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning	☑	Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
☑	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 91-V-1

Citation:
Volpe National Transportation Systems Center, *Port Needs Study (Vessel Traffic Services Benefits) Study Overview*, Cambridge, MA, August, 1991.

Abstract:
This report provides an overview of the three volume report that documents the benefits and costs of potential CG Vessel Traffic Services (VTS) in selected US deep-draft ports (23 study zones). The study uses historical vessel casualties and their consequences and projects future vessel casualties and their consequences for each study zone. Navigational risk is measured in terms of probabilities of vessel collisions, rammings or groundings. VTS benefits are defined as the avoided vessel casualties and the associated consequences measured in physical units and assigned monetary values. The analysis was further decomposed into subzones within each study zone to reflect the different characteristics that were applicable. A total of 99 subzones were examined. The study results in a ranking of the 23 study zones based on avoided vessel casualties and net benefits. The study indicates that VTS is more effective in avoiding collisions than it is in avoiding rammings or groundings. The overview does not indicate the type of vessel casualty avoided. There is no indication that the role of aids to navigation was considered in the analysis.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
☑	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-B-1

Citation:

Brown, K. and Schwenk, J., *Aids to Navigation Service Force Mix 2000 Project: Project Overview*, John A. Volpe National Transportation Systems Center, Cambridge, MA, July, 1992. (DOT-VNTSC-CG-92-2, DOT-CG-N-01-92-1.1).

Abstract:

The project overview describes the purpose, approach, analysis, and results for the ATON SFM 2000 Project. Details are provided in 92-B-2, 92-B-3, and 92-I-1.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-B-2

Citation:

Brown, K., Schwenk, J., Bucciarelli, M, and Jacobs, M., *Aids to Navigation Service Force Mix 2000 Project: Volume I Development and Application of an Aids to Navigation Service Force Mix Decision Support System - Final Report*, John A. Volpe National Transportation Systems Center, Cambridge, MA, July, 1992. (DOT-VNTSC-CG-92-2.I, DOT-CG-N-01-92-1.2).

Abstract:

This volume of the study report documents current ATON operations, the concept, development, and operation of the Decision Support System (DSS), the data utilized by the DSS, the validation of the DSS, and the proposed service force mix. The heart of the analysis is the DSS. The study constructed the DSS using a Geographic Information System (GIS) software program named "TransCAD." This software has a strong built in transportation analysis capability. The DSS is run for each operating area and scenario to find an efficient set of assignments of ATON to platforms and platforms to home ports. The following steps are for all geographic areas to produce a specific fleet size and mix: (1) input data are developed for ATON, vessels, home ports, travel times, and service times; (2) vessels are assigned to home ports; (3) ATON are assigned to vessels; and (4) trip routes are developed and performed for each vessel using a modified traveling salesman algorithm. The DSS models the activities over a one year period and outputs are evaluated. Where necessary, inputs are adjusted to yield outputs that conform with operating guidelines.

The model estimates resource hours for discrepancy response by computing the expected number of discrepancies per aid (from ATONIS and the Buoy Tender Operations Survey, relying on the total survey responses as determinant), and multiplying by the number of aids assigned, and then multiplying by the average time spent servicing an assigned aid (includes service and travel time) that is an output from the DSS. There is no explicit modeling of discrepancies in the DSS model. The results of the study recommended 16 WLBRs and 14 WLMRs.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-B-3

Citation:

Brown, K., Schwenk, J., and Bucciarelli, M, *Aids to Navigation Service Force Mix 2000 Project: Volume II Development and Application of an Aids to Navigation Service Force Mix Decision Support System - Aid Assignments and Vessel Summary Reports*, John A. Volpe National Transportation Systems Center, Cambridge, MA, June, 1992. (DOT-VNTSC-CG-92-2.II, DOT-CG-N-01-92-1.3).

Abstract:

This volume of the study report contains the DSS outputs associated with the findings in Volume I. Included are maps of the aid assignments for each vessel in both the current and proposed fleets and the associated one-page DSS summary printouts.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-C-1

Citation:
Cline, A. K., King, D. H., and Meyering, J. M., Routing and Scheduling Coast Guard Buoy Tenders, *Interfaces*, Vol. 22, May-June, 56-72, 1992.

Abstract:
This paper describes the development and application of a best-schedule heuristic for solving a large class of real-world routing and scheduling problems to the routing and scheduling of buoy maintenance in real time by the United States Coast Guard. The best schedule method reduces a routing and scheduling problem to a traveling salesman problem with non-Euclidean distances. The service windows for the activities are used to prune potential routes without calculating a detailed schedule or evaluating the cost function.

The approach utilizes penalty costs for servicing buoys too early or too late with respect to the service window. The algorithm proceeds in two steps, first finding the best time to visit the buoys on a given route, and the other is to find the best route (best sequence). The approach is illustrated using the USCGC REDWOOD servicing aids in Long Island Sound.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-G-1

Citation:

Grabowski, M. and Sanborn, S., Knowledge-Representation and Reasoning in a Real-Time Operational Control System: The Shipboard Piloting Expert System (SPES), *Decision Sciences*, Vol. 23, No. 6, 1277-1296, 1992.

Abstract:

This paper describes a knowledge representation approach and reasoning implementation in a real-time knowledge-based control system (KBCS) for navigating ships in restricted waters. This shipboard piloting expert system (SPES) is being developed as an intelligent node in Sperry Marine's ExxBridge integrated ship's bridge system (IBS) for Exxon Shipping Company tankers. The SPES is intended to provide design support to ship's navigation officers while piloting large vessels in restricted waters, and to reduce the information overload under which they labor, by incorporating local, transit-specific, and shiphandling knowledge, and by providing requisite decision support in a timely fashion. As such, the system provides decision support to (1) senior ship's pilots training junior pilots; (2) ship's masters training junior deck officers in the essentials of good piloting and shiphandling; and (3) watchstanding deck officers utilizing the system's on-line reminder and assist capabilities, or the off-line simulation and contingency planning functionality. This paper provides descriptions of (1) the theory and practice of ship's piloting decision making; (2) the design of the SPES; (3) knowledge representation and reasoning in the SPES knowledge-based control system; and (4) plans to empirically assess the contribution of the SPES to piloting decision making.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-I-1

Citation:
Ihnat, D., *Aids to Navigation Service Force Mix 2000 Project: Volume III Analysis of Multi-Mission Requirements and Development of Planning Factors for the Replacement Buoy Tender Fleet*, Short Range Aids to Navigation Division, USCG Office of Navigation Safety and Waterway Services, Washington, DC, June, 1992. (DOT-VNTSC-CG-92-2.III, DOT-CG-N-01-92-1.4).

Abstract:
This volume of the report describes the analysis and development of baseline multi-mission requirements of the replacement buoy tender fleet. The document describes buoy tender employment categories, historical tender employment data, the determination of underway hours per underway day, and projected impacts on multi-mission requirements resulting from alternative replacement fleet scenarios. The WLBRs are expected to be "multi-mission" meaning that they will average about 60% of their employment in the ATON mission; WLMRs will be "focused mission" meaning 85% ATON employment. The review recommends 16 WLBRs as the baseline or minimum requirement. A review by the program director indicates that the shortfall in other mission employment is acceptable to responsible program directors. That shortfall will be addressed by other cutters.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-M-1

Citation:

MacRae, B.D., Stephenson, R., Leadholm, T., and Gronin, I., *Digital Chart Database Conversion into a System Electronic Navigational Chart*, USCG Research and Development Center, Groton, CT, March, 1992. (CG-D-15-92, R&DC 04/92)

Abstract:

This report details the activities associated with transforming DX90 data structures to an intermediary Electronic ·Navigational Chart (ENC) format, developing the software to transform this intermediary ENC to a form which could be displayed as a System Electronic Navigational Chart (SENC), and developing display software to allow an operator to interact with the data. Based on these activities, insights were gained into the current status of implementation of the DX90 standard as well as the strengths and limitations of this format to support Electronic Chart Display and Information Systems (ECDIS) applications. The overall conclusion is that the DX90 standard will support these applications, but particular attention must be paid to the various conversions that have to take place.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-S-1

Citation:
Smith, M.W., *Waterway Design Manual*, USCG Research and Development Center, Groton, CT, September, 1992. (CG-D-18-92, R&DC 01/92, NTIS AD-A257030).

Abstract:
This manual provides systems design guidelines that will permit a user to make a meaningful risk assessment of alternative waterway system designs for a given waterway. The manual and software guide the user through an evaluation process for a subject waterway. The general approach is, first, to select a "design vessel" to represent the traffic in a waterway and to divide the waterway into "regions" that will enclose the distance needed by this vessel to perform each of the maneuvers that comprise a transit. Conditions of the transit, including the configurations of the waterway, the short range aids to navigation, and the environmental conditions, are specified as inputs to the program. Based on the input, the program provides a "relative risk factor" (RRF) for each region of the waterway. These values can be used to compare risk in regions along a waterway, or to compare risk under alternative SRA conditions or under alternative conditions. It is emphasized that this is a risk *assessment* tool. This revision of the Waterways Design Manual is the result of over 13 years of man-in-the-loop simulator based research considering ship controllability and aids to navigation. This revision incorporates the latest regression based models reported in Mazurkiewicz, J. and Smith, M.W., *The Effect of Ship Inherent Controllability on Piloted Performance: Evaluation and Prediction*, Interim Report, USCG Research and Development Center, Groton, CT, September, 1991. (CG-D-10-93, R&DC 21/90).

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-S-2

Citation:

Smith, M. W., and Mandler, M. B., Human Factors Evaluations of Electronic Navigation Systems, *Proceedings of the First Annual Conference and Exposition for Electronic Chart Display and Information Systems: ECDIS '92*, Baltimore, MD, February 1992, 113-122.

Abstract:

This paper reviews a series of experiments that were conducted on simulators to evaluate the use of ECDIS-like displays in restricted waterways in reduced visibility conditions. Licensed pilots were used in the simulations of transits of a narrow channel with a 35-degree turn in a deep-draft ship. Early studies in 1980-81 involved simple displays. More complex displays were examined in 1988. A more complex integrated system was examined in 1990-91. The experiments showed that increased display complexity and positioning accuracy had positive effects, especially in the more difficult turn maneuver and in severely-reduced visibility.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
☑	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-S-3

Citation:

Stewart, R. D., and Alexander, L., *Evaluation of Remote Vessel Tracking and Control: Preliminary Trials*, presented at the 1992 RTCM Annual Assembly Meeting, Bal Harbor, FL, 1992

Abstract:

This report describes an evaluation of the feasibility of using a shore-based experimental automated vessel tracking system to control vessel movements, both for trackkeeping and collision avoidance. The experiment was conducted using vessels from the USMMA. The AVTS was located at USMMA from which helm commands were transmitted to the test vessels. The system was used by an experienced Master and by a USMMA Midshipman Cadet. The vessel was equipped with a NavGraphic II integrated GPS/LORAN navigation system. Vessel position information from this system was transmitted to a shore-based ECDIS, Trimble Navigation, Ltd.'s Vessel Tracking and Alert System (VTRACK). Although there was some difficulty in the test subjects remembering the most recent helm orders, both the Master Mariner and the Midshipman Cadet were able to effectively maintain the intended trackline. Another experiment involved the same task using radar. The Master's performance was degraded compared to the AVTS. The Cadet declined to participate because of the difficulty encountered by the master. The Master was also able to effectively control two vessels in a meeting situation using the AVTS, but was unable to do so safely using a shore based radar alone. The recommendations focus on the need for AVTS operators to have significant maritime experience and to have some background and training in computer technology.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 92-U-1

Citation:
US Coast Guard, Office of Navigation Safety and Waterway Services, Chief, *Aids to Navigation Service Force Mix*, Washington, DC, February 1992.

Abstract:
This memo reviews the status of the VNTSC model and its results and evaluates the preliminary analysis that recommends 16 WLBRs and 14 WLMRs. The memo raises the issue that the WLBR is intended to be a multi-mission resource. The VNTSC analysis treats the vessels primarily as dedicated to ATON, although there will be some time available for other mission activity. The memo recommends briefing the senior staff. An issue paper to accompany a briefing for the OCC includes an overview of the effects of reducing the WLB fleet size, but ultimately recommends a fleet of 16 WLBRs.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 93-A-1

Citation:

Alexander L., and Spalding, J. W., *Integrated Marine Navigation Systems of the Future*, presented at the Institute of Navigation National Technical Meeting, San Francisco, CA, January 1993.

Abstract:

This paper reviews the technology used in currently available (1993) marine navigation and positioning systems. The focus is on those systems and components needed for ECDIS and Integrated Navigation Systems (INS). Specific technologies include GPS/DGPS, electronic charts (both IMO-compliant ECDIS, and electronic Chart systems--ECS), and automated radar positioning (circular polarization systems). The paper identifies improvements needed in GPS receivers, GPS/ECDIS interface, high accuracy (GPS-qualified) charts, and primary and secondary positioning sensors. The paper also discusses open architecture requirements.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 93-B-1

Citation:
Brown, K., *Analysis of USCG Replacement Stern-Loading Buoy Boat Requirements for the Aids to Navigation Mission*, John A. Volpe National Transportation Systems Center, Cambridge, MA, August, 1993. (DOT-VNTSC-CG-569-TM-5).

Abstract:
This study extends the analysis provided in the SFM 2000 project to include all of the Coast Guard's smaller buoy handling resources. The DSS developed for SFM 2000 was used to evaluate current and replacement buoy boats. The analysis was restricted to buoy servicing operations. Fixed aids to navigation were considered too diverse to model well since they can be serviced by vehicle, small boat, or other means. In addition, the DSS operates by fully loading available resources. The study concluded that 27 49' BUSLs were required to replace existing boats and to replace WLB/WLM capability reduced by the fleet mix selected in the SFM 2000 study. It also concluded that seven additional BUSLs could assume nearly all of the buoy servicing responsibilities of the two 100' and four 65' WLIs, and that up to ten BUSLs could be effectively employed to assume responsibility for buoys currently assigned to WLICs.

[Note. The report did not make any specific recommendations regarding inland and inland construction tenders. The report was distributed to District Commanders and their review and analyses are included in Appendix E to SRAMA.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 93-B-2

Citation:
Brown, K., Blythe, K., Schwenk J., and West, M., *Overview of the US Coast Guard Short Range Aids to Navigation Mission*, John A. Volpe National Transportation Systems Center, Cambridge, MA, 1993. (DOT-VNTSC-CG-93-2, DOT-CG-N-02-93).

Abstract:
This document provides an overview of the Coast Guard's Aids to Navigation (ATON) mission. Specific components of the mission that are described in the report include: the history of the mission; the supporting Coast Guard organizational structure; the resources employed in servicing ATON; the types of ATON in use by the Coast Guard; and the Coast Guard's preparations for the 21st Century.

[Note. The report provides a good overview of current operations. There is no mention of waterway design, safety and risk. The report indicates that increased use of technology in the future will likely affect the need for visual aids.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
☑	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 93-G-1

Citation:

Grabowski, M. and Wallace, W., An Expert System for Maritime Pilots: Its Design and Assessment using Gaming, *Management Science*, Vol. 39, No. 12, 1506-1520, 1993.

Abstract:

This paper reports on the development and evaluation of a prototype expert system to support the cognitive processes involved in piloting: maneuvering and collision avoidance, and the practice of good seamanship for handling large vessels in close waters. A model was constructed and implemented in a frame- and rule-based representation. The system was assessed using gaming with novice pilots (24 senior cadets from the US Merchant Marine Academy) in the CAORF operational ship's simulator at USMMA. The results showed significant improvement in the bridge watch team performance, but no significant improvement in vessel performance in terms of trackkeeping. The paper concludes with a discussion of the motor, perceptual, and cognitive skills needed for piloting and how they could be supported by expert system technology as part of an integrated bridge system, an operational center for navigational and supervisory tasks aboard a ship.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 93-L-1

Citation:
Lee, J.D. and Sanquist, T.F., *Human Factors Plan for Maritime Safety: Annotated Bibliography*, Battelle Human Affairs Research Centers, Seattle, WA, February, 1993. (CG-D-08-93, R&DC 05/93)

Abstract:
This report summarizes a collection of papers related to the application of human factors to the maritime industry. These papers describe: human factors problems in the maritime industry, research designed to offer solutions, and research in other domains that may apply to these and other potential problems encountered in the maritime industry. This report is divided into six sections, each dealing with a particular area of interest: automation, fatigue/incapacitation, manning, navigation, organizational factors, and training. Each summary includes the complete citation, a synopsis of the methodology used, issues addressed, principal findings, and any technical problems or deficiencies.

[Note: The papers in the navigation section deal with primarily with bridge layout and (electronic) chart issues. These are no papers that deal directly with the process of navigation.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
☑	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 93-M-1

Citation:

Murphy, J. M., *Buoy Maintenance Study Part I*, USCG Maintenance and Logistics Command, Atlantic, September, 1993.

Abstract:

Part I of this study involved a comprehensive review of buoy maintenance activities in Atlantic area, exclusive of the Second CG District considering existing resources and facilities. A primary focus was on the ability of the various buoy maintenance facilities to provide adequate service to the customers (tenders). CAPT Murphy concluded that a major service problem was caused by a shortage of buoy bodies, particularly in the First District. One recommendation of the study was that other districts should send spare buoy bodies to the First District. The study did not address which types should be sent by whom. Several recommendations involved organizational issues, all having the goal of centralizing the management of the industrial facilities and removing industrial functions from primarily operational units (e.g., some Bases). Several recommendations involved methods for extending on-station service life and replacing aids with smaller or less complex aids. The study addresses environmental issues that may affect coatings. Another recommendation calls for an information system that includes the condition of buoys upon relief. The study includes transportation data relative to delivery of aids from the maintenance facilities to the tenders. The study did not include any direct cost analysis. The results and recommendations were based on survey and interview data.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings	☑	Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
☑	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 93-P-1

Citation:
Polant, R.M., The Coast Guard--in the 21st Century, *The Bulletin*, USCG Academy Alumni Association, New London, CT, February 1993.

Abstract:
This paper provides a view of the potential for the use of communications technology in the future Coast Guard. The paper proposes packaging "Global Dial Tone," Differential GPS, Electronic Charts, and Automated Dependent Surveillance as the required "Coast Guard five-mile-an-hour-bumper." The paper predicts that the Coast Guard will become the operator of the ground portion of GPS, and further predicts that the average boater will use GPS and electronic charts.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 93-S-1

Citation:

Spalding, J. W., Flynn, S., and van Diggelen, F., *Servicing and Positioning Aids-to-Navigation with DGPS*, Institute of Navigation GPS '93 Conference, Salt Lake City, UT, 1993.

Abstract:

This paper describes the test and evaluation of a prototype Receiver Autonomous Integrity Monitor (RAIM) algorithm named NAVSAFE developed by NAVSYS, Corp. The test was conducted on USCGC RED WOOD in Long Island Sound. The system operates on a Compaq 486/33 portable computer and interfaces with the LAAPS program. NAVSAFE detects position errors that exceed the user's desired level (10 m 95%) and when the probability of a false alarm exceeds the user's desired level (5%). Depending on the error, a yellow or red alarm is sounded, indicating that the current information is unreliable. During the test, severe thunderstorms knocked the Montauk Point, NY beacon off of the air and positioning continued with the more distant Cape Henlopen, DE beacon. The longer range resulted in some lost data due to transmission problems and problems due to spatial decorrelation. Despite these problems, RED WOOD was able to have a green light about 50% of the time. The experiment also uncovered a multipath problem involving the ship's superstructure when there was a satellite at a low elevation dead ahead (the GPS antenna was located astern of the ship's main mast). This led to the development of a NavPlan module that permits planning work to coincide with good satellite geometry. The evaluation supports the development and use of RAIM in conjunction with DGPS for positioning aids. This provides a measure of the quality of information and also provides documentation of the aid position as a legal document.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-B-1

Citation:

Brown, K., Bucciarelli, M., and Leo, F., *Analysis of Fleet Size and Private Sector Cost Comparisons for the USCG Inland Construction Tender Fleet*, John A. Volpe National Transportation Systems Center, Cambridge, MA, May, 1994. (DOT-VNTSC-CG-94-4, DOT-CG-N-01-94).

Abstract:

This report documents an analysis of inland construction tender requirements. Three areas were examined: a determination of the optimum number of WLICs needed for the construction component of current WLIC work; a comparison of Coast Guard construction tender costs with representative private sector costs; and an assessment of the mission related factors concerning WLICs that need to be considered before reducing the construction tender fleet or contracting for the construction of fixed aids to navigation.

The analysis concludes that 11 WLICs are required for construction purposes (the current fleet is 16); private sector costs exceed those of Coast Guard construction tenders fully employed on construction activities; and mission-related factors – including having the capability of shifting tenders in response to peaks in construction activity and vessel maintenance requirements – need to be included in any decision to alter the size and location of the construction tender fleet. The restriction of WLICs to construction work requires that seven BUSL's be provided for WLIC buoy work.

The analysis was supported by use of the Service Force Mix DSS that had previously been used to determine the WLB/WLM requirements and the BUSL requirements. The SFM DSS was used to partition the construction only activities and use that result in the cost model.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-F-1

Citation:
Fremont-Smith, R., *Study of Feasibility of Changing Minor Lights, Buoy and Daybeacon Servicing Intervals*, Short Range Aids to Navigation Division, USCG Headquarters, Washington, DC, June 1994.

Abstract:
This report includes a summary description of the ATON program extracted from Brown, K., Blythe, K., Schwenk J., and West, M., *Overview of the US Coast Guard Short Range Aids to Navigation Mission*, John A. Volpe National Transportation Systems Center, Cambridge, MA, 1993. (DOT-VNTSC-CG-93-2, DOT-CG-N-02-93). The report then includes the numerous comments regarding discrepancy response, WAMS, and servicing policy collected and reported in Murphy, J. M., *Buoy Maintenance Study Part I*, USCG Maintenance and Logistics Command, Atlantic, September, 1993. The report also includes a letter and comments from the Canadian Coast Guard indicating that it is studying the possibility of relaxing the discrepancy response and servicing policy for Canadian ATON. Based on a review of all of the comments, the study recommends that there is "little need any longer to routinely service USCG minor lights, buoys and daymarkers on a rigid, annual basis". The report recommends a maximum servicing interval for ocean buoys, minor lights and daybeacons of two years and a maximum mooring inspection interval of six years. The recommended change to the Aids to Navigation Manual specifies maximum biennial inspection of buoys and fixed structures. Two years is specified as the normal period between mooring inspections but it may be extended depending on location and wear. Also included is an ATON Servicing Interval Flowchart (SIF) that is intended to assist units in determining appropriate servicing frequencies. Annual evaluation visits are required for each waterway to conduct an overall assessment of all aids in the waterway.

[Note: It is interesting to realize that this recommendation was based only on interviews and qualitative factors. There was no analysis of discrepancy or maintenance data, and no evaluation of the effects on servicing resources. The study was intended to address SRA Measures of Effectiveness, but it concludes that "I have not been able to determine how to address a precise study of the 'relationship between individual SRA availability and USCG SRA waterway systems.'" (p.13)]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
☑	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-F-2

Citation:
Fremont-Smith, R., *United States Coast Guard Ocean Buoy Recapitalization Study*, Short Range Aids to Navigation Division, USCG Headquarters, Washington, DC, September, 1994.

Abstract:
This study addresses the perceived ocean buoy recapitalization funding shortage. The study estimates annual replacement costs of $4 million based on a 20 year life expectancy and an ocean buoy inventory valued at $74 million. The study reviews recent funding history and concludes that an additional $1.8 million is needed to eliminate the current allotment shortage and that annual funding needs to be increased by $1 million (from $3 million to $4 million).

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
☑	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-M-1

Citation:
McLeish, D. B., and Alexander, L., *Buoy Tending with ECDIS: The Future is Now*, presented at the XIIIth IALA Conference, Honolulu, HI, February, 1994.

Abstract:
This paper describes the use of USCGC BITTERSWEET as a test platform for evaluating various ECDIS and related systems since 1990. The ship was used for testing various proposed IMO/IHO standards. The paper reports the common uses of the systems and functionality found useful in normal operations. The paper includes various experiences where the presence of the ECDIS greatly facilitated required tasks as well as permitted operations when they otherwise would have been suspended. The role of ECDIS in normal navigation as well as its use for aids to navigation work is also described. In the latter case, the evaluations indicate significant savings in time required to accomplish ATON tasks.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning	☑	Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-S-1

Citation:

Sanquist, T.F., Lee, J.D. and Rothblum, A.M., *Cognitive Analysis of Navigation Tasks: A Tool for Training Assessment and Equipment Design*, Battelle Human Affairs Research Centers, Seattle, WA, April, 1994. (CG-D-19-94, R&DC 12/94, NTIS AD-A284392)

Abstract:

This paper presents an overview of four different, but complementary methodologies being developed to assess how a given automated system changes shipboard tasks and the knowledge and skills required of the crew. The report focuses on one of these methods, a powerful new application of cognitive analysis. Cognitive analysis identifies the mental demands (such as visual detection, computation and memory) placed on the mariner while performing shipboard tasks. A comparison of the mental demands associated with manual versus automated tasks can highlight differences in the knowledge, skills, and abilities required to perform the tasks. Thus, cognitive analysis identifies changes which may be needed in training and licensing/certification as a result of shipboard automation. The body of the report is a technical documentation of the cognitive analysis method.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-S-2

Citation:
Smith, M. W., Akerstrom-Hoffman, R., Pizzariello, C. M, Siegel, S. I., and Gonin, I. M., Mariner's Use of Automated Navigation Systems, *Transportation Research Record 1464*, 1994.

Abstract:
This report evaluates the performance of two ECDIS systems using a real-time simulation with the simulator at MSI/CAORF. Four masters and two mates each spent a week involved in preparation for and conducting the simulator runs. The scenarios involved transits through the Coastal and Harbor/Harbor Approach phases of navigation in New York or San Francisco. Workload was above normal. The single master/mate was responsible for all navigation, shiphandling, and collision avoidance activities. A single helmsman was provided. The scenarios were designed to have comparable levels of density of events. The two ECDIS systems included Offshore Systems Limited's Precision Integrated Navigation System and Robertson Marine Systems Incorporated's Disc Navigation System. Baseline conditions included plotting on a paper chart, radar/automated radar plotting aid (ARPA), and visual piloting. The ECDIS systems were added either with or without automatic updating of own ship's position, and with or without integrating radar features. ECDIS increased safety, both by decreasing the cross-track distance of own ship from the planned route and by increasing the proportion of time that the mariner spent on look out and on collision avoidance. ECDIS significantly decreased the mariner workload for navigation when automatic updating of position was available. The mariners expressed a preference for a relatively simple chart display for route monitoring, with the immediate availability of a large set of chart information. No measurable effects of radar features on ECDIS were found, although mariners believed that this would be a valuable addition. ECDIS was the primary method of navigation for 67% of the 79 segments when automatic positioning was available. With ECDIS and no automatic position updating, radar/ARPA was the primary method in 61% of the 18 segments. When no ECDIS was available, visual piloting was the primary method for 73% of the 40 segments.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-S-3

Citation:
Spalding, J. W., Flynn, S., Milne, W. and van Diggelen, F., *Interim Report on Servicing and Positioning Aids-to-Navigation with DGPS Incorporating Receiver Autonomous Integrity Monitoring*, United States Coast Guard Research and Development Center, April 1994.

Abstract:
This report documents the development and testing of a Receiver Autonomous Integrity Monitor (RAIM) algorithm named NAVSAFE developed by NAVSYS, Corp. The report contains an overview description of the NAVSAFE RAIM algorithm and the methods used for measuring and detecting errors. The system operates on a Compaq 486/33 portable computer and interfaces with the LAAPS program. NAVSAFE detects position errors that exceed the user's desired level (10 m 95%) and when the probability of a false alarm exceeds the user's desired level (5%). Depending on the error, a yellow or red alarm is sounded, indicating that the current information is unreliable. The operational test was conducted on USCGC RED WOOD in Long Island Sound. During the test, severe thunderstorms knocked the Montauk Point, NY beacon off of the air and positioning continued with the more distant Cape Henlopen, DE beacon. The longer range resulted in some lost data due to transmission problems and problems due to spatial decorrelation. Despite these problems, RED WOOD was able to have a green light about 50% of the time. The experiment also uncovered a multipath problem involving the ship's superstructure when there was a satellite at a low elevation dead ahead (the GPS antenna was located astern of the ship's main mast). This led to the development of a NavPlan module that permits planning work to coincide with good satellite geometry. The evaluation supports the development and use of RAIM in conjunction with DGPS for positioning aids. This provides a measure of the quality of information and also provides documentation of the aid position as a legal document. The system proved to be extremely reliable. In both simulated and actual operational circumstances, where the DGPS receiver was required to perform in marginal signal conditions, the system provided alarms consistently sounded when the navigation solution was outside of the accuracy limits. The program provides measures of the DGPS fix quality on the official aid positioning report. In addition, it records sufficient measurement information to reconstruct the DGPS fix itself and completely analyze the possibility of DGPS errors.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-U-1

Citation:

US Coast Guard, Office of Engineering, Logistics and Development, and Office of Navigation Safety and Waterway Services, *Base/Support Center Industrial Support Roles Focus Group*, Washington, DC, 18 March 1994a.

Abstract:

This study examined potential organizational relationships and managerial responsibility for Bases and Support Centers. A total of five alternative organizations were considered. The reduction in staff at Industrial Support Activities (ISA) (from 1300 in 1961 to 520 in 1994) suggests that some redistribution may be appropriate. The study recommended an organizational concept that will centralize the management of all units with ISAs. It recommended that G-E be the HQPC for both Bases and Support Centers. Some Base ISA activities would be transferred to Support Centers while the Group Engineering functions would remain in place. Some Bases would become Support Centers. Phased implementation is recommended.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
☑	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 94-U-2

Citation:

US Coast Guard, Short Range Aids to Navigation Division, Fleet Development Team, *Short Range Aids to Navigation Mission Analysis SRAMA*, Washington, DC, April 1994b.

Abstract:

SRAMA provides a general description of the SRA program and includes a comprehensive review and analysis of the major ATON analyses that had been conducted since 1970. Based on that review and some additional analyses, SRAMA provides recommendations for a course of action for the program for the following 5-15 year period. The primary recommendation comprises a fleet restructuring plan. The expected savings is $3.8 million per year. The report requires only insignificant changes in the SRA system to achieve the savings. The major recommendations are based on the TSC studies comprising the Service Force Mix 2000.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-B-1

Citation:

Brown, K., Corey, J., and Blythe, K., *Waterways Management Research and Planning Baseline Analyses: Waterways Management*, Volpe National Transportation Systems Center, Cambridge, MA, April, 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-1)

Abstract:

The purpose of this report is to identify the various waterways management functions and organizational elements and their interrelationships. In total, 586 waterways management responsibilities were identified and attributed to 99 different organizational elements. These involved numerous Coast Guard elements, the Army Corps of Engineers, Environmental Protection Agency, and various State agencies. This analysis focused on the 497 "critical" waterways. The report serves as a catalog of responsible agencies. There is some discussion of future technological trends.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-B-2

Citation:
Bucciarelli, M. and Brown, K., A Desktop-OR Success: Modeling Coast Guard Buoy Tender Operations, *Interfaces*, Vol. 25, No. 4, 1-11, July-August 1995.

Abstract:
This paper describes the development of a desktop-OR decision support system that was used to identify replacement requirements for the Coast Guard's 37-vessel seagoing and coastal buoy tender fleet. The system used sophisticated GIS routines to build travel networks and a rudimentary traveling salesman problem heuristic to generate routes. The results recommended a seven vessel decrease representing capital cost savings of $350 million and personnel reduction of 500 billets.

The paper provides a comprehensive overview of how extensive interaction with aids to navigation system personnel developed the insight needed to develop a reasonable model of the buoy tending process. The primary value here was being able to develop an appropriate district wide baseline for validating the model by "forecasting" current operations. While the scheduled servicing process was modeled with the GIS and routing algorithms, The discrepancy response workload was modeled using a deterministic proxy to estimate the expected number of annual discrepancies and estimated the expected time spent in discrepant servicing. A similar deterministic proxy was used to account for time lost to bad weather.

The Coast Guard had determined that the minimum number of seagoing buoy tenders was 16. The model was run assigning only those aids requiring the seagoing tender capability to the capacity provided by the 16 seagoing tenders. The workload was insufficient to fully utilize the tenders. Less demanding aids were then assigned until the capacity was met, and the remaining unserviced aids were then assigned to coastal buoy tenders. The resulting mix was 16 seagoing buoy tenders and 14 coastal buoy tenders. The paper indicates that the total fleet life-cycle cost was dominated by the number of seagoing buoy tenders. Different fleet mix scenarios were examined ranging from 12 to 19 seagoing tenders. The resulting total fleet size remained at 30 for all scenarios except for the 12 case, which required a total of 31 vessels. The conclusion was that the navaid mission requirements determine the fleet size, and the multimission requirements (for the seagoing buoy tenders) determine the fleet mix. The paper reports the results of a sensitivity analysis with respect to changes in weather impacts, vessel speeds, service times, and the hours available for aids to navigation work. A 25% reduction in service time only reduces vessel requirements by one (in Alaska). A 50% change in weather impacts changes the vessel requirements by one (in Alaska). A 250 hour increase in operating time available for ATON (from 1250 hours per year) results in a decrease of eight tenders, while a 250 hour decrease results in an increase of five tenders needed.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
☑	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-C-1

Citation:

Casey, L., Watros, G., and Hall, T., *Waterways Management Research and Planning Baseline Analyses: Navigational Risk Assessment*, Volpe National Transportation Systems Center, Cambridge, MA, April, 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-3).

Abstract:

This report identifies primary navigational risk assessment methodologies, models, procedures, and practices currently used by the Coast Guard. The report analyzes the efficacy of the risk assessment tools and methodologies, including those utilized in making decisions on resource allocation within the Coast Guard, and identifies potential improvements to Coast Guard risk assessment capabilities with respect to current and future risk assessment needs. Specific recommendations for research tasks enhancing current and future risk assessment needs are given. The report notes that there is no standard definition of risk assessment in the Coast Guard. Moreover, District personnel reportedly feel that Headquarters does not give sufficient weight to the WAMS and RRF assessments when making resource allocation decisions. The report recommends research to develop a quantitative risk assessment methodology, a comprehensive waterway risk model, and a resource allocation model

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
☑	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 95-E-1

Citation:

Ecker, W. J. and Alexander, L., The Impact of Emerging Technologies on Waterway Safety and Management, *The Bulletin*, USCG Academy, New London, CT, 27-31, August 1995. (Reprinted from *Sea Technology*, March 1995)

Abstract:

This paper reviews the various elements of the Waterways Management Program and identifies the emerging technologies that may play a significant role in waterways management in the future. The basic needs of waterway uses include safe, effective, efficient, and environmentally-sound waterways. The paper advises that various driving forces, including geo-political, political, and economic concerns as well as new technologies will affect waterways management. The emerging technologies that are addressed include:

- Satellite-based navigation--GPS
- Microcomputers
- Geomatics--science and technology of spatial information management
- New lighting source for navigational ranges, buoys, and fixed navigation aids

Improved systems include:

- GPS/DGPS
- ECDIS
- Improved marine radar
- New buoy system
- New minor light
- Automated vessel tracking

New program initiatives include:

- DGPS broadcast services
- ECDIS updating
- Waterways management assessment that includes:
  waterways design and ATON mix/selection,
  navigation risk assessment,
  waterways project cost/benefit analysis, and
  ATON resource allocation.

Implementation of various initiatives need to be considered carefully because of potential adverse effects and interactions with other users, and the potential for as yet unresolved policy questions. The paper indicated that a new R&D project has been initiated to develop new decision making tools which can be used both to improve waterway and harbor design, and to optimize the use of available funding and resources.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-G-1

Citation:

Grabowski, M. and Sanborn, S., *Shipboard Evaluation of the Shipboard Piloting Expert System (SPES)*, US Coast Guard Research and Development Center, Groton, CT, July, 1995.

Abstract:

This report describes an empirical shipboard evaluation of the *Shipboard Piloting Expert System (SPES)*, a real-time knowledge-based system embedded in the EXXBridge Integrated Bridge System. The experiment examined the SPES's impact on bridge watch team performance and, by extension, on the safety of navigation. An independent variable, voyage stress, was operationalized and measured to account for differing naturally occurring conditions. As expected, the SPES contributed to improved maneuvering and collision avoidance performance as evidenced by multiple measures. When considered in terms of compensating for increased stress levels, the SPES contribution was again found to be better in maneuvering and collision avoidance rather than trackkeeping. The data suggest that the bridge watch team performance is made more uniform with the new technology. Collectively, the results suggest that the SPES technological impact is oriented more towards increasing collective decision quality than minimizing workload.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-G-2

Citation:

Grabowski, M. and Sanborn, S., Integration and Preliminary Shipboard Observations of an Embedded Piloting Expert System, *Marine Technology*, Vol. 32, No. 3, 216-223, July, 1995.

Abstract:

This paper describes the operational evaluation of the Shipboard Piloting Expert System (SPES) that was developed as a value-added module embedded in the ExxBridge integrated bridge system developed for Exxon Shipping Company by Sperry Marine, Inc. SPES is a real time expert system that integrates the information available in various electronic systems available on the bridge intended to provide recommendations and alternatives to ship's pilots and masters navigating in close waters. The operational evaluation was conducted on board *Exxon Benicia* from January, 1992 through August, 1993. The system was found to be helpful to different members of the bridge watch team for different reasons. The system was sufficiently robust and responsive to be of assistance in the piloting and navigation task, and was a useful, value-added enhancement to the integrated bridge system. The evaluation provided valuable insights regarding design requirements for SPES, some of which are easily implemented and others requiring a longer development time. Based on this result, it was anticipated that a full commercial version would be developed as a value-added module to be incorporated with a host integrated bridge system or with an electronic chart display and information system (ECDIS).

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-L-1

Citation:
LaMance, J., Spalding J. W., and Brown, A., *Boosting Shipboard RAIM Availability*, presented at ION Fall Meeting, Palm Springs, CA, September 1995.

Abstract:
This paper describes an autonomous DGPS Fault Detection and Isolation (FDI) algorithm that can be implemented in the user's DGPS receiver. The algorithm is embedded in the NAVSAFE software developed by NAVSYS Corporation. The algorithm makes use of redundant measurements to test the validity of the DGPS solution. The paper provides a good overview of NAVSAFE. Earlier versions of the algorithm were unable to determine whether there was a failure in the algorithm or if the solution was valid in certain circumstances. This generally occurred in cases of low signal-to-noise ratios, poor tracking geometry, and an insufficient number of tracking satellites. In this situation, the RAIM algorithm failed to provide the required integrity information. To augment the RAIM process for this application, additional information is provided to the RAIM software to permit altitude adjusting. In particular, a tide model was added. The modified models were tested in 1994-95 and the results clearly indicate that the altitude adjusting provides the additional information needed to reduce the false alarms and warnings. The paper includes a detailed description of this evaluation process and the evaluation data. With the improvements of the altitude aiding and high accuracy differential corrections, false alarms and warnings have been virtually eliminated. The test results show that NAVSAFE RAIM accurately computes the variance of the noise on the pseudo-range measurements, and reliably detects biases when they occur, and does so in real-time.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-L-2

Citation:

Lunday, M. T., Spalding, J. W., and Dowd, M., *Verification of USCG DGPS Broadcast Parameters*, presented at the Institute of Navigation GPS '95 Conference, Palm Springs, CA, September 1995.

Abstract:

This paper presents the results of performance tests conducted on several state-of-the-art Differential Global Positioning System (DGPS) Minimum-Shift-Keyed (MSK) receivers under varying conditions. The purpose of the effort was to determine the capability of commercially available receivers with respect to proposed USCG DGPS broadcast parameters and to test theorized optimal broadcast parameters (message type and speed) with regard to static noise and carriers/jammer interference. The receivers were tested in three phases: MSK receivers tested under real-time atmospheric noise conditions, DGPS corrections of various ages were received to determine throughput as a function of correction latency, and testing in the presence of controlled CW carrier functioning as an interference/jamming source. The data shows that all of the tested units can receive MSK signals under the proposed USCG broadcast parameters. In the presence of atmospheric noise, message type 9-3 had an advantage over message type 1, agreeing with previous results. All receivers demonstrated vulnerability with respect to interference from other CW signals. Very strong jammers had an effect on the MSK signal reception, even when the jammer frequency was several kHz away from the MSK frequency. This latter observation needs further research.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-M-1

Citation:

Murphy, J. M., *Buoy Maintenance Study Part II*, USCG Maintenance and Logistics Command, Atlantic, February, 1995.

Abstract:

Part II of this study updates assumptions from Part I and evaluates new buoy maintenance arrangements using life-cycle analysis. The update indicates that the buoy body shortage has been addressed and that most of the evaluations of large foam buoys are not identifying good options. The closing of Support Center New York resulted in transferring that maintenance responsibility to South Weymouth. No specific recommendations were made for the Fifth District facilities because D5(oan) indicated that they could resolve the problems. The Florida/Gulf Coast problem included seven alternatives that were examined in a life-cycle cost analysis. CAPT Murphy recommended that Base Charleston and Base Mobile continue to function and that the maintenance at Base Miami, Base Mayport, and Galveston be contracted out. Appendices to the study include detailed cost data for all buoy maintenance functions, transportation, and capital improvements.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
☑	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs	☑	Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-M-2

Citation:
Maio, D., Nabrynski, J., and Long, D., *Waterways Management Research and Planning Baseline Analyses: Waterways Users*, Volpe National Transportation Systems Center, Cambridge, MA, April, 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-2).

Abstract:
This study defines initial categories of waterway users and their quantifiable attributes -- all types and sizes of water vehicles used to transport people or goods in commerce, and those used recreationally or in performing government functions. The study identifies existing and potential sources of data for these attributes, defining those that must be quantified to support navigational risk assessment, measurement of effectiveness of Coast Guard aids and services, and the estimation of the monetary benefits of proposed changes. Quantifiable generic attributes at the national or regional level and those that must be quantified at the level of individuals waterways are identified. Waterway user requirements for navigational information and human factors are explored. Specific recommendations for research tasks are presented.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
☑	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-M-3

Citation:

Maio, D. and Watros, G., *Waterways Management Research and Planning Baseline Analyses: Project Overview*, Volpe National Transportation Systems Center, Cambridge, MA, April, 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-5).

Abstract:

This report is an overview of the four baseline analyses conducted with the objective of developing tools to assist Coast Guard and District headquarters managers in allocating limited resources objectively and assuring that the Coast Guard's system of aids to navigation and waterways services remain responsive to the changing requirements of waterways users. The baseline topics include:

- Waterways management
- Waterways users
- Navigational risk assessment
- Management systems effectiveness and benefits estimating

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-S-1

Citation:

Smith, M. W., Akerstrom-Hoffman, R., Pizzariello, C. M, Siegel, S. I., Schreiber, T. E., and Gonin, I. M., *Human Factors Evaluation of Electronic Chart Display and Information Systems (ECDIS)*, Department of Transportation, United States Coast Guard Research and Development Center, February 1995. (CG-D-12-95, R&DC 10/93, MSI/CAORF 26-9038-01A).

Abstract:

This report describes a study done to examine contributions that ECDIS might make to the operational practices on the commercial bridge. Issues examined were: the contribution to the safety of navigation, the effect on the navigational workload, the features required during route monitoring, and the potential contribution of integration with radar.

Two commercially available ECDIS systems were installed on the simulator bridge at MSI/CAORF. Four masters and two mates each spent a week involved in preparation for and conducting the simulator runs. The scenarios involved transits through the Coastal and Harbor/Harbor Approach phases of navigation in New York or San Francisco. Workload was above normal. The single master/mate was responsible for all navigation, shiphandling, and collision avoidance activities. A single helmsman was provided. The scenarios were designed to have comparable levels of density of events. The two ECDIS systems included Offshore Systems Limited's Precision Integrated Navigation System and Robertson Marine Systems Incorporated's Disc Navigation System. Baseline conditions included plotting on a paper chart, radar/automated radar plotting aid (ARPA), and visual piloting. The ECDIS systems were added either with or without automatic updating of own ship's position, and with or without integrating radar features.

ECDIS increased safety, both by decreasing the cross-track distance of own ship from the planned route and by increasing the proportion of time that the mariner spent on look out and on collision avoidance. ECDIS significantly decreased the mariner workload for navigation when automatic updating of position was available. The mariners expressed a preference for a relatively simple chart display for route monitoring, with the immediate availability of a large set of chart information. Radar integration, as implemented on the devices used, did not provide the ARPA information that mariners required.

The report provides a detailed description of the performance measures, experimental design, and analyses conducted. It also includes a comprehensive list of references as they pertain to human factors with radionavigation methods.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-S-2

Citation:
Spalding, J. W., and van Diggelen, F., *Positioning United Sates Aids-to-Navigation Around the World*, presented at the Institute of Navigation GPS '95 Conference, Palm Springs, CA, September, 1995.

Abstract:
This paper analyzes the potential use of GPS+GLONASS (GNSS) receivers to provide position information of sufficient accuracy to permit positioning of aids to navigation in those areas where the Coast Guard does not maintain a Differential GPS capability. The data presented demonstrates that this technology can meet Coast Guard requirements for buoy positioning. The paper develops the various definitions and computations necessary to determine acceptable positions based on specified values of 2DRMS. This formulation is then used to determine the maximum acceptable error value (2DRMS) that will be acceptable for position various (accuracy) classes of aids. This is then used to translate into limiting values of GPS+GLONASS performance. Using an Ashtech GG24 receiver with a Receiver Autonomous Integrity Monitoring (RAIM) algorithm to compute the various statistics needed to estimate 2DRMS, data was collected for a 66 hour period. The desired accuracy (by Coast Guard standards) of 10 m was achieved 40% of the time. Because of the accuracy classifications of the different aids, larger values of 2DRMS would be acceptable. The report provides data for USCGC SASSAFRAS (Hawaii). Finally, the paper describes a prototype software for positioning buoys using a GPS+GLONASS receiver. The GPS+GLONASS receiver technology shows promise for replacing the use of horizontal sextant angles for positioning USCG aids to navigation around the world. Field tests are recommended.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
☑	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-U-1

Citation:
US Coast Guard, *Waterway Analysis and Management System Completion Guide*, Washington, DC, January, 1995.

Abstract:
This document is designed to provide field units and District (oan) with a step by step guide to completing a Waterways Analysis and Management System (WAMS) report. The report provides helpful hints on how to accomplish the various tasks. Although the step by step intent should be reflected in a corresponding sequence in the guide, there are clearly places where some feedback and iteration will be required. The guide identifies a number of areas to be examined, but does not give specific guidance as to how that is to take place, or what kind of evaluation is to be made. This is clearly problematic for an initial WAMS report, less so for a review WAMS report.

[Note: The guide is probably very useful, but it lacks clearly defined objectives for a WAMS report and no overall organization of a WAMS evaluation. If a primary objective is to evaluate the adequacy of the *system* of aids to navigation in the waterway, the objective will be missed because there is no focus on a systems view. The justification for computing the RRF is very strained. The guide could benefit from a review taken from a systems perspective by someone not terribly familiar with the WAMS process. There is nothing in the Guide to indicate who prepared it or who has continuing responsibility for its maintenance.]

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies	☑	ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 95-W-1

Citation:

Winkeller, R., Watros, G., and Weber, A., *Waterways Management Research and Planning Baseline Analyses: Management Systems Effectiveness and Benefits Estimating*, Volpe National Transportation Systems Center, Cambridge, MA, April, 1995. [DRAFT REPORT] (DOT-VNTSC-CG-95-4)

Abstract:

This report explores the use of performance measures and a performance measurement system as a framework for measuring the effectiveness of improvement efforts. The report provides background on the definition of performance measures and methodologies for developing such measures; reviews some examples of "best practices" in performance measurement; describes current Coast Guard practices for measuring the performance of waterways management; and recommends specific research tasks.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 96-B-1

Citation:
Brown, G. G., Dell, R. F., and Farmer, R. A., Scheduling Coast Guard District Cutters, *Interfaces*, Vol. 26, No. 2, 59-72, March-April, 1996.

Abstract:
This paper describes an optimization model developed to schedule Coast Guard District cutters to quarterly patrols and standby status for search and rescue, law enforcement, and pollution control. The model was implemented for the First Coast Guard district involving 16 cutters. Each cutter is assigned weekly to one of six statuses to ensure patrol coverage, enforce equitable distribution of patrols, and honor restrictions on consecutive cutter statuses. The problem is modeled as an elastic mixed-integer program that yielded face-valid schedules that were superior to the manually prepared ones. Implementation of the model is hampered by the turnover of Coast Guard personnel. The working prototype lacked a slick interface that would facilitate the model's use. The authors suggest that the lack of an interface and the personnel turnover are possible explanations for the lack of use of computer-based analytic models for Coast Guard planning.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology		Advanced Technology
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
☑	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability/Safety		Navigability/Safety
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 96-G-1

Citation:

Grabowski, M. and Georg, J. C., Integrated Bridge Systems Performance, Expert Systems and Human Performance, *Proceedings of the Public Forum on Integrated Bridge Systems*, National Transportation Safety Board, Tysons Corner, VA, March, 1996.

Abstract:

This paper provides a state-of-the-art review of the development of integrated bridge systems and intelligent piloting systems. The paper predicts a need for distributed intelligent piloting systems that will make the relevant information available to several ships and shore-based VTS personnel simultaneously using the same display. The paper reviews human performance using integrated bridge systems focusing on the empirical and operational evaluations of the SPES. The paper concludes that intelligent piloting systems are best considered as value-added enhancement to an integrated bridge or and ECDIS, rather than standalone systems. Few intelligent piloting systems have been developed which provide expert decision support for *all* types of piloting knowledge. Substantial advances in reasoning, reliability and decision enhancement can be produced by integrating shipboard navigation systems (including piloting expert systems) with vessel traffic services and real time port environmental data.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 96-G-2

Citation:

Gonin, I., Dowd, M. K., and Alexander, L., *Electronic Chart Display and Information System (ECDIS) Test and Evaluation, Summary Report*, United States Coast Guard Research and Development Center, December 1996. (CG-D-20-97, R&DC 39/96).

Abstract:

This summary report describes four sea trials and one man-in-the-loop simulator experiment conducted by the USCG Research and Development Center from 1990 to 1993 to thoroughly test and evaluate the adequacy of the International Maritime Organization's Performance Standards for ECDIS. The specific experiments include:

- October, 1990 initial sea trials
- October, 1991 T/V KINGS POINTER sea trials
- September-October, 1992 MSI/CAORF simulator experiments
- January-April, 1993 BITTERSWEET & KINGS POINTER sea trials

Issues examined include: the contribution to safety of navigation, the effects of the navigation workload, features and functions required during route monitoring, and the contribution of integration with radar. Each of the five tests were designed to incorporate known methodology and advanced technology to thoroughly test the contributions that ECDIS might make to the operational practices on a ship's bridge. As the experiments progressed, the technology became more sophisticated, with information being sought in more breadth and depth. Each experiment, building on the findings of the previous, was designed to ask more in depth questions, to gain more complete information. This four year effort is one of the most comprehensive studies done on ECDIS performance.

There are several key findings produced by this body of work. It was shown consistently that ECDIS with automatic position updating can provide equivalent or greater safety than the paper chart and more traditional methods of navigation. Another key finding is that navigation workload is reduced, allowing the mariner to concentrate on collision avoidance or other tasks of similar importance. In the area of user-interface design, it was found that the mariner wanted an "uncluttered" display during route monitoring, with more features available if needed.

It is important to emphasize that ECDIS without automatic position updating created at least as much navigation workload as the conventional bridge arrangement in both the simulator experiment and the follow on sea trials. The results from this series of experiments contributed significantly to the development and revision of the IMO standards for ECDIS.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 96-H-1

Citation:
Heerlein, W., *A Catalog of Information Resources from a Waterways Management Perspective*, U.S. Coast Guard Research and Development Center, March 1996.

Abstract:
This report presents the results of a study to identify present Coast Guard waterways data. The identified systems are categorized and described in terms of their content, capability, and access. The following systems were identified.

Category 1--active Coast Guard systems with essential waterways data

- Light List--annual 7 volume publication. Electronic read-only through DMA's NAVINFONET.
- Waterways Analysis and Management System (WAMS)--paper reports evaluating individual waterways. Available in district offices.
- Automated Relative Risk Factor (ARRF)--computer program to compute the RRF used in evaluating waterway safety.
- Aids to Navigation Information System (ATONIS)--relational database recording features of aids to navigation and servicing. Separate data bases maintained in district offices.
- Laptop Automated Aid Positioning System (LAAPS)--real-time software application design to position floating aids to navigation. Operates in a laptop environment.
- Navigation Information Service (NIS)--public information service involving radionavigation data associated with GPS, DGPS, OMEGA, and LORAN. Available through an electronic bulletin board and WWW.
- Geographic Display Operations Computer (GDOC)--software application that displays maps and nautical charts used primarily at operations centers to plan SAR operations.
- Marine Safety Information System (MSIS)--historical records of marine inspection activity and incidents with over 250 "products" prepared for various users. Various subsystems perform specific analyses.
- Spill Planning Exercise And Response System (SPEARS)--provides centralized location for accessing data necessary for spill response. Implemented on Apple MacIntosh computers at MSOs and NSF.

Category 2--planned Coast Guard systems with potential waterways data

- Marine Safety Network (MSN)/Ports and Waterways Management Information System (PAWMIS)/Merchant Mariner Documentation System (MMDOC)
- Marine Information, Safety and Law Enforcement (MISLE)/Marine Safety Network (MSN)/Vessel Identification System (VIDS)
- Operations Information System (OIS)
- VTS-Upgrade/Automated Dependent Surveillance (ADS)/VTS-2000
- Waterways and Navigation Data Services (WANDS)/ Local Notices to Mariners (LNM) Automate
- Bridge Information Systems (BRIDGIS)

Category 3--other Coast Guard systems with some data relevant to waterways

- Automated Mutual-Assistance Vessel Rescue System (AMVERS)
- Search and Rescue Information System (SARMIS)
- Law Enforcement Information System II (LEIS II)

Category 4--other systems (non-Coast Guard)

- Internet/WWW
- DOT Bureau of Transportation Statistics
- NOAA
- US Army Corps of Engineers
- MARAD
- Lockheed Martin MTM/Halcrow-Integraph PIMS

The study revealed that most data cannot be easily accessed because it is stored locally at unit and district offices. Redundant data were found in some of the systems. The report identifies developments such as moving to an open architecture that has the potential for making data more accessible. The role of the Internet is also explored.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning	☑	Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
☑	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 96-N-1

Citation:

National Research Council, *Vessel Navigation and Traffic Services for Safe and Efficient Ports and Waterways, Interim Report*, Marine Board, NRC, Washington, DC, 1996

Abstract:

This report comprises a review of the VTS-2000 program considering public/private sector roles, need for new or improved waterways management services, feasibility and implementation of VTS and other services, identification of beneficiaries of those services, and available funding methods. The study was initiated by the perception that the climate has changed since the project was started seven years prior. The 1991 study (based on 1989 data) that identified 17 ports for VTS installations was characterized as out of date and incomplete as to risk measures. Potential beneficiaries questioned the need for advanced systems and were hesitant about user fees. The study concluded that the technology to improve navigation safety was available, but the impediments involved funding and institutional issues. The study concluded that the existing Coast Guard-operated VTS systems are well-managed and make a significant contribution to port safety, although no quantitative data were found to substantiate improvements to safety and efficiency. The study recommended that the Coast Guard revisit the needs analysis for VTS and pursue public/private partnerships to establish baseline systems in critical areas. This should be followed in other ports on a phased basis. The report recommends developing alternative cost-sharing options.

[Note: The report (Table 2-1) indicates that there is a need for improvement and expansion of traditional navigation aids in certain ports. There is no further documentation in the report to identify or support this conclusion.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
☑	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 96-S-1

Citation:
Spalding, J. W., Lunday, M. T., and Dowd, M. K., *Differential Beacon Receiver Testing*, United States Coast Guard Research and Development Center, June 1996. (CG-D-24-96, R&DC 18/96).

Abstract:
This report reviews the development of the requirements for a differential beacon receiver that receives the digital broadcast of DGPS corrections over the marine beacon band (285-325 kHz). The sole purpose of the receiver is to provide the DGPS corrections to a properly configured GPS receiver which then applies those corrections in its navigation process to yield position accuracy of 2-10 meters. In order to conclude the research effort, the R&DC conducted a campaign of testing to validate the methods being used in the Coast Guard DGPS service.

This report includes the results of performance tests conducted on several state-of-the-art Differential Global Positioning System (DGPS) Minimum-Shift-Keyed (MSK) receivers under varying conditions. The purpose of the effort was to determine the capability of commercially available receivers with respect to proposed USCG DGPS broadcast parameters and to test theorized optimal broadcast parameters (message type and speed) with regard to static noise and carriers/jammer interference. The receivers were tested in three phases: MSK receivers tested under real-time atmospheric noise conditions, DGPS corrections of various ages were received to determine throughput as a function of correction latency, and testing in the presence of controlled CW carrier functioning as an interference/jamming source. The data shows that all of the tested units can receive MSK signals under the proposed USCG broadcast parameters. In the presence of atmospheric noise, message type 9-3 had an advantage over message type 1, agreeing with previous results. All receivers demonstrated vulnerability with respect to interference from other CW signals. Very strong jammers had an effect on the MSK signal reception, even when the jammer frequency was several kHz away from the MSK frequency. Further research into interference should focus on a study of what typical man-made interference exists in major ports and evaluate the receiver's ability to deal with it.

Coast Guard DGPS broadcast methods were evaluated and found to be sufficient for broadcast of the DGPS corrections. The results also led to the recommendation to change all DGPS broadcasts to 200 bits per second using the RTCM SC104 Type 9-3 broadcast option (from Type 1 at 100 bits per second). The benefits of this change would be improved performance for the users of the system and simplification of the system as all beacon broadcasts would be at the same rate.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 96-S-2

Citation:
Spalding, J. W., and Crowell, R. D., *Performance Test Results of DGPS and DPS Testing on USCGC Juniper (WLB-201)*, United States Coast Guard Research and Development Center, September 1996.

Abstract:
This report contains the performance test results of the Differential Global Positioning System (DGPS) and the Dynamic Positioning System (DPS) of CGC JUNIPER. The tests were conducted near Milwaukee, Wisconsin in March 1996, and near the Race in Long Island Sound in July 1996. This evaluation was done to support the Independent Operational Test (IOT) located at the R&D Center in their task of independent test and operational evaluation of the Juniper class. The DGPS test results confirm that the system installed aboard JUNIPER is capable of achieving 2-meter fix accuracy with a 95% probability. The DPS test results also indicate that in moderate wind and wave conditions, the system installed aboard JUNIPER is capable of achieving 10-meter station keeping with a 95% probability. In rougher conditions, including combinations of wind and current, the system degrades to 12 meters and needs rudder assistance to compensate for the lack of thruster power. The dockside test of the DGPS in Milwaukee, at a wharf including several large cranes, stacks of containers, and other equipment, yielded an accuracy of 3.1 meters over a 15 hour period of continuous (every 15 second) sampling. It is believed that this was due to some blockage of satellite signals and creation of multipath effects. The test also observed several large "spikes" in the data up to 24 meters. This is a similar effect reported by Leica, Inc. (WLB shipboard receiver manufacturer) on the Point Loma, CA broadcast. It was found that these were due to the DGPS broadcast and corrective action has been taken by the EECEN.

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning	☑	Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 96-V-1

Citation:
Volpe National Transportation Systems Center, *Waterways Evaluation Tool Functional Requirements*, Initial Draft, Cambridge, MA, March 15, 1996.

Abstract:
This report documents the state of development of the functional requirements for a Waterway Evaluation Tool (WET). Previous research had identified the need for decision support tools to assist in waterways management. WET is the first such tool to be developed and it is intended to facilitate the comprehensive evaluation of the performance of waterways. The report indicates that the analysis/redesign of a waterway is called for in the existing Waterways Analysis and Management System (WAMS), but it is not done in a comprehensive and consistent manner among districts and over time. Additionally, the WAMS process is very resource intensive. The purpose of WET is to provide a mechanism for consistent and more comprehensive analysis with a requirement for fewer resources to complete the evaluation. The report suggests that the resulting product will be useful for selecting and funding AC&I projects nationwide.

The report describes the approach that will be used in WET and provides some examples. The approach primarily involves the use of value trees to evaluate both the performance and importance of waterways. With these two measures, a Significant Performance Index is computed that provides a baseline measure of performance with respect to the most important function(s) of the waterway. Separate value trees will be developed for each of five Coast Guard strategic goals. The value trees use both objective and subjective scoring procedures. The subjective scoring typically involves a 1 - 5 scale. Weights for the various elements are provided for general waterways, but certain users may specify particular weights for given waterways. For most performance elements, an additive approach is used to aggregate the scores. The report only contains partial information on the various value trees.

[Note: The proposed methodology using value trees makes some unstated assumptions about the value functions (e.g., risk status, mutual preferential independence) that should be acknowledged and considered somewhere. The method by which the weights for the various elements and sub-elements are obtained for an individual waterway is not described in the functional requirement. The general waterway weights were developed by the Technical Advisory Team using Groupware (method not specified). The issue of interpersonal value/utility comparisons has not been addressed. The report would lead one to believe that evaluations of different waterways by different users can lead to meaningful comparative results. This is one of the remaining unresolved issues in decision theory and stands as a roadblock in the application of WET. With respect to SRA and RA, their location in the mobility value tree seems to indicate a diluted importance (simply from the structure of the tree) for those elements. While WAMS may not be giving a good systems analysis of the waterway, it is not clear that WET as proposed in this report will either.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures	☑	Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
☑	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 96-V-2

Citation:
Volpe National Transportation Systems Center, *Waterways User Groups Characterized According to the Navigational Requirements of the Vessel Operators*, Final Report, Cambridge, MA, August, 1996.

Abstract:
This report represents another in a series of studies conducted to assist the Coast Guard in Waterways Management. The specific purpose of this task is to define waterway users by navigational requirements and to select particular user groups for in-depth study. Unlike the baseline analysis where waterway users were defined as vessels (defined by use and characteristics), this study identifies "operators" (the individuals operating the vessels) as the users of aids to navigation. In this study, ATON are broadly defined. Operators are characterized by their navigational environments, skills, and navigational equipment. The study was intended to identify what users actually use particular types of ATON or perceive that such aids are necessary. The study anticipates the reduction in particular types of aids (e.g., visual) as other aids (e.g., electronic) become more available and accepted. The study also indicated that new shore-based aids may replace floating aids. The report indicates that the results are based on face-to-face and telephone interviews of representatives of Boat/US, USCG 1st District staff, and interviews with more than 20 experienced mariners who represent various categories. The report includes a ranking of the operators in two categories: vessel operations and navigational capability using an index. The operator responses of dependence/use are then use to profile the operator dependence on each type of aid. The report suggests that this methodology could be used to obtain operator input with respect to proposed changes in aids to navigation in given waterways. The study discusses groups for more in-depth study without making any specific recommendations. The discussion specifically mentions recreational boaters, smaller coastal passenger boat operators, and the tug-barge trade. The study suggests that deep draft vessel masters do not be considered as a group because their dependence on ATON is counterbalanced by the fact that they must carry a pilot and are under a legal mandate to be equipped with navigation systems and crew trained to operate them.

[Note: The report does not indicate how many total interviews were conducted or how many interviews were conducted in each category. Nor does the report indicate the operating environmental differences that may result in different behaviors by operators in the same class in different geographical areas. The interviews do not attempt to identify how the various ATON are used or how they interact or substitute for other aids. There is no description of the development and computation of the indices for vessel operations and navigational capability that are used to rank the operators.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
☑	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)	☑	Waterway Design (Aid Location etc.)

ID: 97-C-1

Citation:
Creamer, P. M., Cho, D. L., Morris, P. B., and Pisano, J. J., *Differential GPS Mission Needs Analysis: Harbor Entry and Approach*, TASC, Reading, MA, November 1997. (TIM-08605-1).

Abstract:
This report describes the derivation of DGPS service requirements to meet harbor entry and approach mission needs. The report also includes an analysis of arguments which might be used to defend the Coast Guard's DGPS service in admiralty litigation. The requirements analysis focuses on DGPS providing navigation information in low/zero visibility conditions equivalent to current levels of operation/casualties when used in conjunction with a baseline suite of other onboard navigation systems. The purpose of the report is to define appropriate levels of accuracy, integrity, availability, reliability, and coverage for DGPS. The starting point is defining a target level of safety (TLS) associated with an acceptable level of risk. The study estimates a nationwide average TLS using data from the 1991 Port Needs Study based on 23 ports for medium/large cargo/tanker casualties. The ship-hour weighted average is 3.2×10^{-4} incidents/ship-hr. for the medium/large cargo/tanker class. The study uses 3×10^{-4} incidents/ship-hr. as the nationwide baseline TLS to be achieved using DGPS. The Port Needs Study did not include navigation failure and/or error as one of the causes of incidents. In the current analysis, four incident categories (operator errors, errors in judgment, failure to account for currents, and failure to maintain position control) that comprised 30% of the incidents were assumed to represent shortcomings of the navigation function. Consequently the portion of TLS attributable to navigation was 9×10^{-5} incidents/ship-hr. The study then apportions this navigation risk equally among undetected failures, detected failures, and no DGPS failures. The detected failures were divided equally between backup design risk and integrity design risk. The report notes that other allocations will yield different results. The study used failure mode analysis and Markov chain analysis to assess design parameters for the following parameters:

- DGPS Service MTBF
- Design Service MTTR
- Protection limit
- Time to alarm
- Beacon receiver MTBF
- Position plotter MTBF
- GPS receiver MTBF

The study applies this methodology to estimate the parameter values needed to meet the Navigation TLS in four harbors: Tampa Bay, Delaware River, Long Beach, and St. Mary's Rock Cut. The study found that significant equipment improvements will be required to the nationwide Navigation TLS in Tampa Bay and St. Mary's Rock Cut. The study characterized two sets of specifications: one for "typical" procedures, and one for "challenging" procedures. The study recommends developing an implementation plan for the most cost-effective and timely method of implementing the DGPS requirements specified for typical and challenging harbors. A second recommendation involves conducting tests to verify that DGPS service requirements are being met.

[Note: In the analysis leading to system requirements, it is not clear that the effects of joint use of other electronic aids (e.g., radar) in conjunction with DGPS is being considered as a possibility. The study assumes that the average TLS will/should be applied uniformly. The Tampa Bay casualty rate in the Port Needs Study was 1.52×10^{-3}, nearly 5 times the average TLS of 3.2×10^{-4}. Using their analysis, the nominal DGPS installation appears to provide a level of service as good as the existing system in Tampa Bay.]

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 97-G-1

Citation:
Gonin, I., and Crowell, R., *Assessing Electronic Chart Systems*, United States Coast Guard Research and Development Center, March 1997.

Abstract:
This report provides the results of the CG R&D Center's evaluation of several commercial Electronic Chart Systems (ECS) for use aboard Coast Guard cutters. A secondary purpose of the report is to provide insight into the RTCM Recommended Standard for ECS that may assist individuals in the procurement, development, regulation, and policy setting for ECS. The R&D program was initiated to examine the proposed RTCM standards for Electronic Chart Display and Information Systems (ECDIS). The results of the research have led to revision of the ECDIS standards and the development of standards for ECS. The current research included an operational valuation of three commercially available ECS for use on Coast Guard vessels. Three different systems were installed on four different cutters. The highest level system included radar integrated with the ECS. The report includes an evaluation of each system installation. Based on that evaluation, the report includes guidance for choosing an ECS. The guidance addresses the functionality described in the RTCM standard and provides additional guidance based on the experience from the evaluations. The report recommends that the Coast Guard partner with ECS manufacturers and pursue a COTS acquisition policy rather than developing its own system. The operational evaluation was conducted in 1994. The report includes additional information on more recent systems (1997) and discusses future issues (raster chart data vs. vector data).

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 97-S-1

Citation:

Spalding, J. W., and Alexander, L., *United States Coast Guard Integrated Ice Navigation System Research*, United States Coast Guard Research and Development Center, January 1997.

Abstract:

This research examined issues regarding the integration of ice navigation systems and ECDIS for navigation in ice infested waters. The research was initiated by CGHQ indicating a desire to have the R&DC develop an integrated system. The R&DC took advantage of an ongoing research effort by the Canadian government to explore similar issues for ice operations on the Canadian frontier. The R&DC partnered with the Canadians (and others) to evaluate an ice navigation support system. The structure of the system included a separate ECDIS that passed waypoint information to and from a separate Ice Navigation and Support System (INSS). The researchers concluded that developing a stand alone integrated system was beyond the scope of the resources available for the project and was going to be technically very difficult. The system also included information from a circular polarized Arctic Marine Radar (AMR). The system was tested in a field trial on the M/V ARCTIC during Fall/Winter 1995. The evaluation concluded that the use of the ECDIS/INSS/AMR system was very helpful and that integrated electronic charting technologies improve icebreaker operations and provide valuable ice information to vessels that transit ice areas. The exchange of waypoint information using a standard National Marine Electronic Association (NEMA) interface for routes and waypoints and IHO S-57 data objects for ice information processed by the INSS would assure interchangability between manufacturers for either ECDIS or INSS components. The study concluded that the Coast Guard should use separate ECDIS and INSS components rather than develop and maintain an integrated system. It was felt that the market would be too small for any manufacturer to make a serious effort at developing such a device.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 97-S-2

Citation:
Spalding, J. W., and Crowell, R. D., *Performance Test Results of DGPS and DPS Testing on USCGC IDA LEWIS (WLM-551)*, United States Coast Guard Research and Development Center, July 1997.

Abstract:
This report contains the performance test results of the Differential Global Positioning System (DGPS) and the Dynamic Positioning System (DPS) of CGC IDA LEWIS. The tests were conducted enroute to and near the Race in Long Island Sound in March 1997. This evaluation was done to support the Independent Operational Test (IOT) located at the R&D Center in their task of independent test and operational evaluation of the KEEPER class. The DGPS test results confirm that the system installed aboard IDA LEWIS is capable of achieving 2-meter fix accuracy with a 95% probability. The DPS test results also indicate that in specified wind and wave conditions, the system installed aboard IDA LEWIS is capable of achieving 10-meter station keeping with a 95% probability. The report includes the results of the DGPS accuracy test and the station-keeping tests. Three of the five tests involved conditions outside of the sponsor's requirements. In two of those tests, IDA LEWIS was unable to achieve 10 meter accuracy. Most of the positioning involved using the DGPS broadcast from Sandy Hook, NJ (nearly 100 miles). Performance was not as good as when the closer Montauk Point radiobeacon was used.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning	☑	Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 97-U-1

Citation:
US Department of Transportation/Department of Defense, *1996 Federal Radionavigation Plan*, Washington, DC, July 1997.

Abstract:
The Federal Radionavigation Plan (FRP) delineates policies and plans for radionavigation services provided by the U.S. Government to ensure efficient use of resources and full protection of national interests. Developed jointly by the U.S. Departments of Defense and Transportation, the FRP sets forth the Federal interagency approach to the implementation and operation of radionavigation systems.

The FRP is updated biennially. This ninth edition describes respective areas of authority and responsibility, and provides a management structure by which the individual operating agencies will define and meet requirements in a cost-effective manner. Moreover, this edition contains the current policy on the radionavigation systems mix. The constantly changing radionavigation user profile and rapid advancements in systems technology, require that the FRP remain as dynamic as the issues it addresses. This edition of the FRP builds on the foundation laid by the previous editions and further develops rational plans towards providing an optimum mix of radionavigation systems for the foreseeable future.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning	☑	Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems	☑	Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
☑	Radionavigation Aids		Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 97-U-2

Citation:

US General Accounting Office, *Coast Guard Challenges for Addressing Budget Constraints*, GAO/RCED-97-110, Washington, DC, May 1997.

Abstract:

This report discusses the fiscal constraints that the U.S. Coast Guard is facing and efforts that the agency is making to adjust to constrained budgets. The report contains recommendations to the Secretary of Transportation and two matters for congressional consideration to assist the Coast Guard in meeting its budget targets. The report predicts a substantial funding shortfall since the allocated budget increase will simply cover retirement commitments. The cost savings due to streamlining while substantial, will not be adequate to cover future shortfalls. The report recommends revisiting missions to determine what is really essential and what services should be supported directly by user groups. The report cites several initiatives and analyses. It notes that the International Ice Patrol Mission Analysis study attempted to identify costs of Coast Guard performance and other alternatives. The report supports earmarking user fees to be returned to the agency rather than the general treasury account. The report cites the self-inspection of private aids to navigation as a cost saving measure representing a new way of performing the mission. It also cites the Coast Guard's openness to alternative structures for VTS implementation that will result in reduced costs.

PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION	
	Advanced Technology (DGPS, ECDIS, ARPA, etc.)	☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements	☑	Customer Identification/Requirements
	Human Factors		Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis		Modeling and Analysis
	Navigability, Safety, Risk	☑	Navigability, Safety, Risk
☑	Operating Costs		Operating Costs
	Personnel Requirements	☑	Personnel Requirements
	Radionavigation Aids		Radionavigation Aids
	Servicing Mix	☑	Servicing Mix
	Systems Cost Issues	☑	Systems Cost Issues
	Vessel Positioning		Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)

ID: 98-R-1

Citation:

Ryan, S., Petovello, M., and Lachapelle, G., Augmentation of GPS for Ship Navigation in Constricted Water Ways, *Proceedings of ION NTM 98*, Long Beach, CA, January, 1998.

Abstract:

This paper examines the positioning accuracy improvement that is obtained by augmenting DGPS with single point GLONASS, differential GLONASS, and height constraint. The alternatives were evaluated by running a simulation over a 24 hour period. Field trials were conducted at the University of Calgary under various GPS and GPS-GLONASS masking angles. For both the simulation and the field trials, the availability and reliability performance were analyzed as a function of signal obstruction elevation and the types of augmentation that were implemented. The report examines the reliability of the DGPS installations operated by the Canadian Coast Guard. Although the broadcast DGPS corrections are reliable, a reliable position for the user is not guaranteed because of possible problems such as: user multipath, user receiver blunders, troposphere or ionosphere modeling problems, or masking effects resulting in a weak geometry. Six positioning methods were analyzed:

- DGPS alone
- DGPS and a height constraint
- DGPS and GLONASS
- DGPS, GLONASS and a height constraint
- DGPS and DGLONASS
- DGPS, DGLONASS and a height constraint

These methods were analyzed under four isotropic mask angles (5, 10, 15, and 20 degrees). The simulation and the field test results showed that augmentation of DGPS with GLONASS and DGLONASS improved both the reliability and the availability of the navigation system. The relative effects were more pronounced as the mask angle increased. The best conditions were observed with DGPS augmented by DGLONASS and a height constraint

	PRIMARY CLASSIFICATION		SECONDARY CLASSIFICATION
☑	Advanced Technology (DGPS, ECDIS, ARPA, etc.)		Advanced Technology (DGPS, ECDIS, ARPA, etc.)
	Aid Positioning		Aid Positioning
	Aid System Performance Measures		Aid System Performance Measures
	ATON Policies		ATON Policies
	Buoy/Beacon Design, Hardware and Moorings		Buoy/Beacon Design, Hardware and Moorings
	Buoy Tender Technology		Buoy Tender Technology
	Customer Identification/Requirements		Customer Identification/Requirements
	Human Factors	☑	Human Factors
	Information Requirements/Systems		Information Requirements/Systems
	Maintenance and Logistics		Maintenance and Logistics
	Modeling and Analysis	☑	Modeling and Analysis
	Navigability, Safety, Risk		Navigability, Safety, Risk
	Operating Costs		Operating Costs
	Personnel Requirements		Personnel Requirements
	Radionavigation Aids	☑	Radionavigation Aids
	Servicing Mix		Servicing Mix
	Systems Cost Issues		Systems Cost Issues
	Vessel Positioning	☑	Vessel Positioning
	Waterway Design (Aid Location etc.)		Waterway Design (Aid Location etc.)